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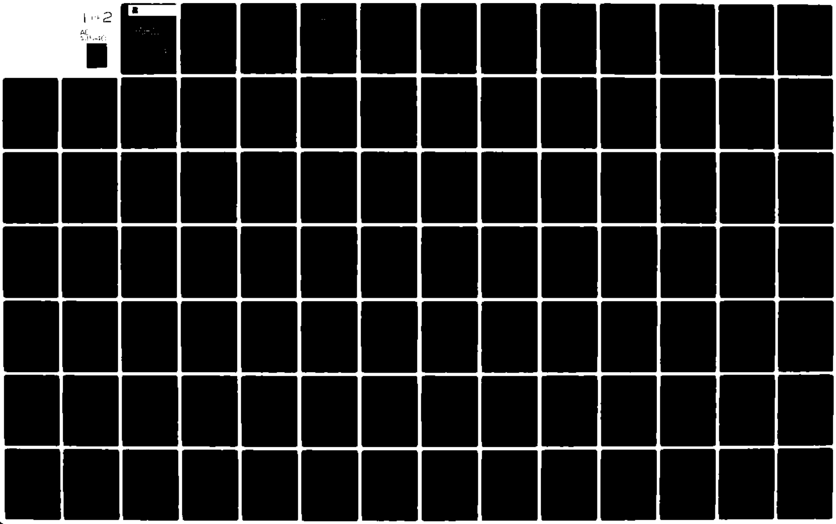

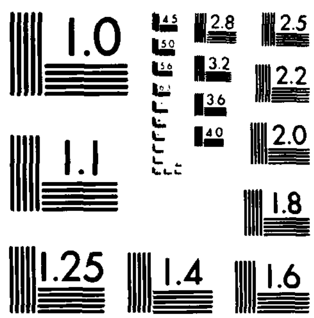

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This is a survey of developments in computer science in five areas of the world outside the United States with principal emphasis on Japan. Most of the information was obtained from documents and other sources available in the United States. The one exception is the trip report of three authors who visited Japan in October 1981.

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INTERNATIONAL DEVELOPMENTS IN COMPUTER SCIENCE

A Report Prepared by the
Standing Panel to Survey International Developments in Computer Science
Computer Science and Technology Board
Commission on Physical Sciences, Mathematics, and Resources
National Research Council

NATIONAL ACADEMY PRESS
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NOTICE: The project that is the subject of this report was approved by the Governing Board of the National Research Council, whose members are drawn from the councils of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The members of the Committee responsible for the report were chosen for their special competences and with regard for appropriate balance.

This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

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This study was supported by the Office of Naval Research.

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PREFACE

For several decades the United States has been the leader in electronic technology and computer science. Now many nations are mounting research efforts that challenge our technological supremacy. As the markets for products and services grow, the competition among the leading postindustrial nations grows as each nation tries to stake its claim.

The United States can no longer afford to ignore the fact that many nations will sooner or later match or even surpass our expertise in computer science. We need to become better informed about their activities so that we can remain competitive. Of course, scientists, academic institutions, industrial organizations, and government agencies do monitor pertinent developments individually. Nevertheless, there is a need for an interdisciplinary approach to the gathering of information on computer science that would consolidate uncoordinated and often replicated efforts under one roof.

In May 1980 a "Proposal for a Panel to Survey International Developments in Computer Science" was submitted by the Computer Science and Technology Board of the National Research Council (NRC) to the Office of Naval Research (ONR). The panel was to make "an inventory of information available in the United States about those countries believed to be leaders in computer science and technology." The project was expected to take about six months and require a panel of 10 individuals "selected on the basis of scientific and technical excellence and an appreciation of computer science activities in other countries."

This project, which we have called Phase I, received preliminary approval in September 1980. The Standing Panel to Survey International Developments in Computer Science was chartered to combine the talents and experience of a number of multilingual computer scientists from industry, government, and academia. The panelists were recommended by the Board and approved by the chairman of the NRC. They have experience with computer science developments in many countries and markets and joined with enthusiasm and dedication to prepare this initial study.

The first panel meeting was held in Washington, D.C., on January 29, 1981. All panel members were present, as well as a number of visitors, including Marvin Denicoff and Robert Grafton of ONR. During this meeting, the panelists agreed that only a few carefully selected geographic areas could be examined in the allotted time. They chose

five and divided the panel into five sections to study them. The responsibilities were assigned as follows: Japan--George Lindamood, Norihisa Suzuki, and Tadao Murata; Western Europe--David Gries and Robert Dewar; Eastern Europe and the USSR--Tania Amochaev, Albert Traynham, Valentin Turchin, and Robert Dewar; Latin America--Enrique Marban, who resigned from the panel in March 1981 because of growing business commitments and was subsequently replaced by V. Sadagopan; and People's Republic of China--H.T. Kung and Norihisa Suzuki.

In Phase I, the panelists were to make an assessment of foreign language computer science publications in terms of (1) their quality and quantity, (2) their timely availability, in the original or in English, and (3) their relevance and significance. The linguistic barriers encountered ranged from almost nonexistent, to Cyrillic script in Eastern Europe, to the formidable ideographs of the Far East. Large volumes of abstracts, articles, conference proceedings, and source periodicals were examined; international directories and computer-readable data bases were consulted; even translations made for use within companies did not escape the panel's attention.

For two months the panelists studied their respective areas, receiving occasional suggestions from the sponsor. Documents were collected and distributed; a variety of conceptual approaches to information gathering were formulated; and a significant informational data base began to develop.

The second panel meeting took place on April 22-23, 1981, again in Washington, D.C. Progress reports were received from four of the five subcommittees (Dr. Sadagopan had not yet been appointed to replace Mr. Marban).

During the next two months, panel members continued to gather and exchange information, data, and documentation in preparation for the third and final meeting, which was held at the National Academy of Sciences Conference Center at Woods Hole, Massachusetts, on June 25-26, 1981. H.T. Kung could not attend, but he sent in a precis of his report. Albert Traynham (Control Data Corporation) attended in place of Tania Amochaev. After giving brief status reports, the panel members drafted sections of the final report, including summaries, conclusions, and recommendations for geographic areas. Their individual studies were prepared with the cooperation of other panel members, who suggested relevant materials and applicable research methodologies and supplied special documentation. During July and August 1981 the panel members wrote and edited their respective contributions to this final report.

Throughout the project, the panel chairman, Carl Hammer, and the Computer Science and Technology Board's executive director, Jacob F. Blackburn, wrote monthly progress reports and meeting reports, which were sent to the panel members and ONR.

The panel is grateful to the Computer Science and Technology Board for having taken the initiative and obtaining approval for this project from the NRC and to ONR for its sponsorship of this work.

SUMMARY

The most industrialized nations are, not surprisingly, those doing the most significant work in electronics. Much information on this work is being published in these nations. Many U.S. computer scientists are not aware, however, of developments in computer science abroad. Language barriers are largely responsible for this lack of awareness. The Standing Panel to Survey International Developments in Computer Science recommends that a number of steps be taken (see the recommendations in Chapter 7) to ensure that the scientists in the United States will be better informed in the future.

Most papers published or delivered at conferences by Western Europeans are in English. Consequently, it is not difficult for the United States to keep abreast of their work. Eastern European work is to a large extent ignored by Americans. More attention should be paid to this work, as some of the analytical approaches to problems appear to be novel and advanced.

The most advanced work in computers is being done in Japan. Since only about 20 percent of Japan's computer science publications are in English, it is important that a method be found to make American computer scientists more aware of their work. Additional translations, more visits to Japan by computer scientists, and collaborative research efforts with the Japanese would be helpful.

The computer research now being done in Latin America is not advanced enough to be of interest to the United States. However, substantial progress may soon be made in some Latin American countries, e.g., Brazil and Mexico, and thus we should monitor developments there.

Because of the great size of China's population combined with its commitment to rapid technological development, it is likely that substantial progress in computer science will be made there in the next decade. It is therefore highly important to keep up with developments in China. More translations and more scientist-to-scientist contacts are needed.

The panel recommends that a Phase II of its work be undertaken. This phase would take two years and would provide a much deeper analysis of the international developments in computer science. Phase II would produce a plan for an ongoing procedure designed to keep the United States more fully informed about overseas developments in computer science.

Chapter 1

DEVELOPMENTS IN JAPAN

BACKGROUND

In computer science the Japanese have come from a position of essentially no activity to second place in the world in 20 years. They now have half as many computers as the United States, and their growth rate is double that of the United States. Virtually all Japanese computer firms are multinational companies.

In Japan the computer industry is one of the strategic industries on which the Japanese hope to build their future. The Ministry of International Trade and Industry (MITI) has identified the furtherance of this industry as one of the "national projects" to which special management attention and funds are to be devoted. A large-scale commitment has already been made for this purpose, and groups of corporations have been organized to work on the project.

The main organizations concerned with the computer field are as follows:

- The Ministry of International Trade and Industry, the executive entity of which is the Agency of Industrial Science and Technology (AIST). This agency possesses a number of laboratories; one of them is the Electrotechnical Laboratory (ETL), which performs outstanding computer research, coordinated with national projects.
- The Ministry of Posts and Telecommunication (MPT), which administers Nippon Telephone and Telegraph Public Corporation (NTT) as well as Kokusai Denshin Denwa (KDD), an international communication agency. NTT has its own laboratory (Electrical Communication Laboratories (ECL)), and KDD also has its own laboratory. ECL is quite similar in function to Bell Telephone Laboratories (BTL). The quality of R&D work being done in the computer field at ECL is roughly on a par with that at BTL, although not as fundamental in approach.
- The Ministry of Education, Science, and Culture (MESC). As of 1979, 33 universities (27 national), including major schools such as Tokyo University, Kyoto University, Osaka University, Tohoku University, and Tokyo Institute of Technology, had computer science departments, with a total student population of about 1600; 23 of these universities had graduate schools where most of the basic research in computer science was being done, all sponsored by the MESC. Computer centers

are usually operated in conjunction with these departments. The largest of these centers, and perhaps the largest in the world of its kind, is at Tokyo University. This center has eight Hitachi M-200H central processors with all necessary peripherals in operation, serving as many as 750 remote terminals.

- The Agency of Science and Technology, at the subministry level. This agency has a number of laboratories; one of them is the Institute of Physical and Chemical Research, where some computer-related research is performed.
- The following primary companies (those extensively engaged in the manufacture, sales, and service of computing systems): Fujitsu, Hitachi, Nippon Electric Corporation (NEC), Toshiba, Mitsubishi, and Oki. The following secondary companies (those in which the computer business is a comparatively small part of the total business): Matsushita, Sony, Sharp, and Nippon Minicomputer.

From 1971 to 1980, the Pattern Information Processing System (PIPS) has commanded a lot of attention. The government's investment of $100 million has underwritten a number of interconnected PIPS systems:

- a printed-character recognition system (Toshiba),
- a handwritten-character recognition system (Fujitsu),
- a shaded-pattern recognition system (Toshiba),
- a color chart recognition system (Mitsubishi),
- an object pattern recognition system (Hitachi), and
- a voice pattern recognition system (NEC).

Although the quality of PIPS is somewhat in question, the program has developed a cadre of trained and experienced people spread throughout the Japanese industry. Their potential value in developing a fifth-generation computer is significant.

Fujitsu

Fujitsu made the earliest and most important commitment to computers. It participated in all MITI projects. In addition, it built Japan's first digital relay computer in 1935 and the FACOM 100 Relay machine in 1954, and announced the 230 Series of five compatible models in 1964.

In December 1972, Fujitsu reached an agreement with Amdahl concerning technical information exchange, and Fujitsu acquired 24 percent equity in Amdahl for $6.2 million. In August 1974 it was announced that the Amdahl 470 V/6 would be built in Japan. The Amdahl alliance gave creditability to Fujitsu. This is the first of the three elements needed for success according to the Japanese: creditability, profitability, and innovation.

In June 1973, PANAFACOM, Ltd., was formed as a joint venture between Fujitsu and Matsushita. In 1973, Fujitsu Espana S.A. was

founded jointly with the Credit Bank of Spain to import computers and communications equipment from Japan to Spain.

In September 1973, Fujitsu and Hitachi formed Nippon Peripherals Ltd. (NPL) to perform jointly R&D, manufacturing, and marketing. In November 1974, Fujitsu and Hitachi came out with a joint line called the M-Series in response to IBM's announcement of the 370 System. They called it the 3.75 Generation. The M-190, announced in November 1974, was the first of the M-Series. Fujitsu signed an "other equipment manufacturer" (OEM) agreement with Siemens for its M-200, M-180 II AD, and OS IV/F4 operating system.

Fujitsu is now marketing their smaller computers through TRW in the United States. Fujitsu and Amdahl have agreed that the M-190 will not be marketed in Europe but the M-180 and the M-200 will be. Fujitsu is now the sixth largest computer company in the world in terms of revenue.

Hitachi

Hitachi is a large conglomerate company that makes railroad locomotives, industrial cranes, and home appliances as well as computers and components. Hitachi first used parametron technology in its computers but soon switched to transistors.

In 1961, Hitachi signed a technology exchange agreement with RCA. In 1965, the HITAC 8000 Series was announced and was based on the RCA Spectra Series, which was also compatible with the IBM 360 Series. In 1966, Hitachi was made the prime contractor on MITI's super computer. This led to the development of the HITAC 8700 and 8800. Many models of the M-Series have been announced since October 1971, including the M-180, M-170, M-160 II, and M-150. In September 1975, Hitachi revealed discussions with Control Data Corporation (CDC) to market the M-Series. In March 1976, Hitachi announced an OEM agreement under which the American company ITEL would provide AS/6 central processing units (CPUs). The agreement was later extended to the AS/7. The agreement was renewed with the National Advanced Systems Corporation (NASCO) after ITEL's demise.

In September 1978, Hitachi announced the M-200H as the world's largest and fastest computer, at 12.8 millions of instructions per second (MIPS), which was about 10 percent faster than the Fujitsu M-200 and 60 percent faster than the IBM 3033. The memory capacity is 16 MB, using 16 K N-type metallic oxide semiconductor (NMOS) chips. The CPU uses emitter-coupled logic with 550 gates per chip and has 64-KB buffer memories using 16 K bipolar chips. It has an optional integrated array processor.

Fujitsu also announced in September 1978 a mass storage system "media" compatible with the IBM 3850. In 1979-1980, Hitachi made marketing arrangements for its computer systems in Europe with BASF, Olivetti, and Saint Gobain. In 1980, Hitachi announced a disk equivalent to the IBM 3380 for delivery in 1982.

Nippon Electric Corporation

Nippon Electric Corporation (NEC) was established in 1899 as a subsidiary of Western Electric. Today NEC is a producer for Satellite Business Systems of the United States. It is Japan's largest manufacturer of communications equipment. It produces and markets 14,000 products in 100 countries and is the world's largest producer of satellite communications, earth stations, and microwave communications systems.

NEC announced a transistorized computer at the Paris World Exposition in 1959. The NEAC 1201, which used parametron technology, was announced in 1961. Until 1965, NEC was Japan's largest computer manufacturer. It eventually lost its lead to Fujitsu and Hitachi because of reduced R&D efforts in computers and increased emphasis on communications. Since 1971, NEC has established a joint line with Toshiba. NEC is responsible for the ACOS 200, 300, 400, and 500, and Toshiba is responsible for the ACOS 600, 700, 800 I and II, and 900 I and II. The 800 and 900 were joint developments. In September 1980, NEC announced the ACOS System 1000 as the world's largest. Model 1 is rated at 15 MIPS, and model 2 at 29 MIPS. Production is estimated at 80 units over a five-year period. The first shipment will be made in October 1981.

Toshiba

In 1952, Toshiba collaborated with Tokyo University on a vacuum tube computer. It was installed in 1954.

Toshiba announced its first commercial computer, the TOSBAC 4200, in December 1961, and in 1964 the TOSBAC 3400 was announced. Also in 1964 a technical agreement was signed with General Electric (GE). The TOSBAC 5400 was based on the GE 400, and the TOSBAC 5600 was based on the GE 600. In 1978 came Japan's first 32-bit minicomputer, the TOSBAC series 7, model 70.

Mitsubishi

Mitsubishi was the last of the six primary companies to begin working in computers. Their earliest computer was similar to the Bendix G 15, a scientific machine. But after IBM announced the 1401, a commercial machine, Mitsubishi ordered over 30 of them, thus indicating their interest in commercial as well as scientific computers. MITI suggested holding down imports, and so in 1962 Mitsubishi made an agreement with TRW to use the TRW 53 as a basis for a new computer called the MELCOM 1530. The MELCOM 3100 and MELCOM 9100 followed in 1966.

In 1968, the MELCOM 80 super minicomputer series came out, and it has sold well in Japan. After TRW's withdrawal from data processing (DP), Mitsubishi signed an agreement with Xerox Data Systems. The MELCOM 6500 and 7700 followed. In 1971, Mitsubishi and Oki teamed up to produce the COSMO Series. In 1975, Mitsubishi teamed with Fujitsu and Hitachi for very large scale integration (VLSI) development.

Mitsubishi announced in August 1978 that in 1979 it would begin development of a line of computers that would be compatible with those of IBM. There was some delay in completion of the COSMO 900 II, announced in December 1979. In January 1980, Mitsubishi announced plans to market a plug-compatible machine (PCM) system by 1983.

Oki

Oki is the third largest communications equipment manufacturer, after NEC and Fujitsu. Oki produced a transistorized computer in 1959. In September 1963, Oki Univac KAISHA (OUK), Ltd., was formed. The OUK Series is based on the UNIVAC 90 Series. Oki's financial position has weakened since the oil crisis of 1973. Oki Electronics of America was formed in 1972, and Oki Data Corporation in 1973. Oki has similar operations in Germany and Brazil.

Nippon Telephone and Telegraph

Nippon Telephone and Telegraph (NTT) is the second largest phone company in the world (after ATT). It designs equipment to be manufactured by Japanese manufacturers on license.

NTT spends about 2 percent of its revenue on R&D. NTT, KDD, and Tokyo University built Japan's first parametron computer in 1953-1957. Beginning in 1968, NTT developed the Dendenkosha Information Processing System (DIPS). Beginning in early 1971, Fujitsu, Hitachi, and NEC cooperated in developing the DIPS I, which followed the experimental DIPS 0.

DIPS II consisted of the models 10, 20, and 30, developed by Hitachi, NEC, and Fujitsu, respectively. As of 1978, 26 DIPS I CPUs had been installed. Installation of DIPS II machines began in 1977. A second DIPS II development program began in 1978. Prototypes were due in 1981.

NTT has a Data Communications Network Architecture, which was developed in 1977 with Hitachi and Oki but is not yet in operation.

Japanese Government Efforts

In 1954, when the first American computer was exported to Japan, Japanese companies expressed concern about future American dominance in this industry. In 1955, a budget of $2200 was established to organize a Computer Research Committee. The committee recommended encouraging development activities, introducing foreign technology through technical assistance and licensing, and limiting imports of foreign computers. By 1961 the value of domestically produced computers in Japan was $13 million, and foreign machines held 70 percent of the market.

A 1966 report of the Electronics Industry Deliberation Council set the following objectives for the computer industry:

- independent technological excellence,
- increased domestic market share, and
- gradual rise in domestic manufacturing and in profits.

In 1971 the "Law for Extraordinary Measures for Specific Electronic and Machinery Industries" was enacted. Six Japanese companies were paired off to form Nippon Peripherals, Ltd. (NPL), NEC-Toshiba Information Systems (NTIS), and FACOM-Hitachi, and $350 million was committed to a VLSI effort for the period 1976-1979. Support for software houses was confirmed by the government in 1978.

In July 1979, the Electronic Computer Basic Software Technology Research Association (ECSTRA) was established to develop the basic technology of the next generation of computers. A budget of approximately $260 million over 1980-1984 was established.

Among the trends MITI sees developing in the 1980s are the following:

- Increased market conflict and instability arising from energy problems and nationalism.
- A decline in U.S. hegemony and intensified multipolarity.
- A more assertive global leadership role for Japan commensurate with its economic status as a "great power."
- A shift from improving imported technologies to developing indigenous ones.
- An upgrading of energy and computer technology.

During this period, Japan's priorities include survival under the threat posed by energy problems and trade protectionism, and stable growth of its industry.

THE SITUATION TODAY

As indicated in the previous section, in the late 1960s Japan adopted as a national goal the development of a strong indigenous computer industry. Their accomplishments have been impressive: Japanese semiconductor technology rivals that of the United States as the world's finest, and, although the Japanese still admit a comparative deficiency in software, their computer systems are highly respected for performance and reliability.

All this has served to heighten worldwide interest in Japanese computer science and technology, but this interest has been dampened somewhat by the language barrier. Not only does written Japanese involve Kanji ideograms as well as two (Kana) alphabets of 50 characters each, the Japanese language itself denotes a cultural outlook much different from our own. The language barrier is moderated somewhat by the fact that English is used extensively as a second language in Japan. In the public schools, students routinely learn to read English and virtually all top Japanese scholars, businessmen, and government officials are able to write and converse easily in English. This, coupled with what appears to be a Japanese cultural propensity to

collect data and publish reports on all aspects of their society, means that a considerable amount of information on Japanese computer science and technology is available in English.

Nevertheless, few U.S. computer scientists are well informed about Japanese activities. About 75 percent of all Japanese scientific papers and 86 percent of Japanese engineering papers are published only in Japanese. Moreover, some of the English-language publications are not widely known in the United States, and some of the available ones are rather expensive. Although many top Japanese computer scientists seek worldwide recognition through publication in English, many of their papers are first published in Japanese and only later submitted in English to overseas journals. In addition, many first-rate Japanese computer scientists are not active internationally: they choose to publish only in Japanese and to participate only in intra-Japan professional activities.

The most respected Japanese publications in computer science and technology are The Transactions of the Institute of Electronics and Communication Engineers (IECE) of Japan (Denshi Tsushin Gakkai Ronbunshi); Joho Shori Gakkai Ronbunshi; and the Proceedings of the Information Processing Society of Japan (IPSJ). The first of these is concerned with electronics, communications, and computers; the other two are oriented more toward software and applications.

For U.S. computer scientists, Sections C, D, and E of the Transactions of the IECE are of primary interest: Section C contains articles on integrated circuits; Section D contains articles on computers; and Section E contains articles written in English. However, other sections may contain articles of interest on audio and TV technology, solid-state physics, and robotics.

Both Joho Shori Gakkai Ronbunshi and the Proceedings of the IPSJ are published by IPSJ, the former in Japanese and the latter in English. Although the two journals are more or less equal in scope and prestige, they do not, as a rule, contain the same papers.

Both Joho Shori Gakkai Ronbunshi and the Transactions of the IECE contain English-language abstracts provided by the authors of the articles published. In addition, translations of selected papers from the latter are published in Electronics and Communications in Japan, by Scripta Publishing Company of Silver Spring, Maryland. However, Scripta may discontinue this activity because of financial difficulties. (The National Science Foundation terminated its financial support of this activity in 1970.)

Industrial research and development activity in Japan also yields a number of technical papers of high quality. Japanese industrial computer scientists often present these papers at the annual conferences of the IPSJ or the semiannual conferences of the IECE. The proceedings of these conferences are published in Japanese. Other specialized papers are presented at the monthly meetings of the various special interest groups (SIGs) of the IPSJ and the IECE and are published in Japanese in the proceedings of those SIGs.

Japanese authors who publish in English for international audiences tend to use the Proceedings and various Transactions of the Institute of Electrical and Electronics Engineers (IEEE), the various publications

of the Association for Computing Machinery (ACM), and Acta Informatica, all of which are published in the United States. Japanese representation is also strong at the (U.S.) National Computer Conferences held annually and at the triennial conferences of the International Federation of Information Processing (IFIP).

Because of the considerable Japanese industrial research activity in computer science and technology, the publications of Japanese companies and the "trade press" may also contain information of interest to the practicing computer scientist. Among the former are the Fujitsu Science and Technical Journal, Hitachi Review, NEC Research and Development, and the (NTT) Review of Electrical Communications Laboratories. The NEC publication is an English-language newsletter; the others are published in both English and Japanese, the Japanese edition appearing earlier and being more complete.

Trade press publications of interest include the Computer White Paper, published annually in Japanese and English by the Japan Information Processing Development Center (JIPDEC), and the JIPDEC Report, published quarterly in English. JIPDEC was established in 1967 with the support of both the government and private industries. It is a nonprofit organization whose function is to promote research and development in computer applications. In addition to its publishing activities, the organization plans conferences. Ninety percent of the funds come from the government (as part of the profits from bicycle race gambling), and ten percent come from private industries. On the other hand, the Information Technology Promotion Agency (IPA), which was established in 1971, is a quasi-government organization supported primarily by the government.

Other English-language publications include the following: Japan Computer News, a monthly newsletter from the Japan Electronic Computing Company (JECC); Japan Fact Book, published annually by DEMPA Publications using data collected by the Japan Electronics Industry Development Association (JEIDA), a trade association for computer manufacturers; EDP Japan Report, published at least once a month by International Data Corporation (IDC) Japan, a subsidiary of the U.S. firm IDC; and Asian Computer Monthly, published in Hong Kong by Computer Publications, Ltd.

In addition to the publications in Japanese that we have already mentioned, others that merit attention are as follows: Joho Shori, a monthly publication on tutorials; JECC Computer Note, published annually by JECC, a leasing company for computers founded by Japan Development Bank (government owned); Joho Sangyo Benran, a biannual report on the information industry, published by Joho Sangyo Shimbun; Nihon Joho Shimbun, a daily newspaper giving news of "information industries and markets"; Gekkan Computer Digest, a monthly clipping service covering the top 10 Japanese newspapers; and Nihon Keizai Shimbun, a daily economics journal published in Tokyo.

In addition to these sources, most Japanese computer firms and trade associations produce brochures and press releases about their products and activities. Although some view such items as little more than propaganda, they do provide an indication of Japanese interests. Many of the press releases are reported regularly in the U.S. industrial

and trade press, e.g., in Business Week, Computer Business News, Computer World, Datamation, Electronic News, Electronics, Lambda, and the Wall Street Journal.

The U.S. government also collects and disseminates some information on computer-related developments in Japan. The Smithsonian Scientific Information Exchange (SSIE) maintains an on-line data base on research and development. The Joint Publication Research Service (JPRS) prepares translations for various federal agencies and publishes the JPRS Japan Report. Some of the translations are available to the general public through the National Technical Information Service, in Springfield, Virginia. The Office of Naval Research (ONR) maintains a liaison office in the U.S. Embassy in Tokyo and publishes items of interest in the ONR Technical Report.

The main sources of information on computing in Japan are summarized in Tables 1-1 and 1-2.

According to the Scripta Publishing Company, which has done some translations for the Transactions of the IECE, "Under optimal conditions, the time lag between publication of a Japanese journal and its English equivalent should be no more than six months." However, during the trip to Japan by Murata and Kobayashi, discussed in the following section, several Japanese authors stated that the time was about two years for them.

JAPAN'S VIEW OF FUTURE DEVELOPMENT

Substantial insight into Japan's plans for future development is to be found in the computer research plan outlined at the International Conference on Fifth-Generation Computer Systems held in Tokyo during October 1981. Hisashi Kobayashi of the IBM Research Center, Tadao Murata of the University of Illinois, and Robert B.K. Dewar of New York University were among those attending that conference, and their reports are given below. It is evident from the report by Kobayashi and Murata that the Japanese plan is innovative and ambitious. In addition to describing the plan, Kobayashi and Murata give an account of their visits to research laboratories and universities in Japan. Dewar, in his report, gives an assessment of the Japanese plan.

Kobayashi and Murata's Report on the International Conference on Fifth-Generation Computer Systems

FGCS Conference

The first International Conference on Fifth-Generation Computer Systems (FGCS) was held in Tokyo, on October 19-22, 1981. The conference was organized by JIPDEC and supported by MITI. There were 325 participants from 16 countries. Among them, about 100 were from abroad: 45 from the United States, 12 from the Federal Republic of Germany (FRG), 11 from the United Kingdom (UK), 7 from France, 7 from Italy, 4 from India, 3 from the People's Republic of China, 2 from Canada, 2 from

TABLE 1-1 American Sources of Information on Computing in Japan

Professional Journals	Newspapers and Other Publications, Specific
Communications of the Association for Computing Machinery (ACM)	Computer Business News
Computer	Computer World
Computing Reviews	Datamation
Computing Surveys	EDP Industry Report
Institute of Electrical and Electronics Engineers (IEEE) Spectrum	EDP Japan Report
IEEE Transactions on Computers	Electronic Engineering Times
IEEE Transactions on Software Engineering	Electronic News
Journal of the ACM	Electronics
Proceedings of the IEEE	
General Publications	**Governmental Sources**
Business Week (special issue 12/14/81)	Central Intelligence Agency
Science	Defense Intelligence Agency
The Wall Street Journal	Joint Publication Research Service (JPRS)
	National Technical Information Service
Consulting Firms	Office of Naval Research
The Gartner Group, Stanford Connecticut	U.S. Department of Commerce
International Data Corporation, Waltham, Massachusetts	U.S. Department of State
Arthur D. Little, Inc., Cambridge, Massachusetts	U.S. Embassy in Japan
Quantum Sciences Corporation	

Mexico, and 1 each from Belgium, Bulgaria, the Netherlands, Sweden, Czechoslovakia, and the Philippines. All speakers, except for six invited lecturers and several invited panelists, were Japanese and gave their presentations in Japanese, using slides written in English. Simultaneous interpretations from Japanese to English or English to Japanese were provided throughout the conference.

A major purpose of the conference was to present the preliminary planning studies that have been prepared by the FGCS committee and working groups (approximately 100 people) in the past two and a half years. The research goals and plans of the FGCS project were presented by 12 speakers (6 from MITI's ETL, 3 from the University of Tokyo, and 1 each from Keio University, NTT Laboratory, and Matsushita) who were all chairmen or key members of various study groups within the FGCS committee: First, Tohru Moto-oka, chairman of the committee, gave an

TABLE 1-2 Japanese Sources of Information on Computing in Japan

<u>Publications in English</u>
Computer Conferences
Computer White Paper
JIPDEC Report
Journal of Information Processing
Look Japan
Proceedings of USA--Japan
Yearbooks, Japan Annual Reviews in Electronics, Computers and Telecommunications (to be published by OHMSHA, Tokyo, and Elsevier/North Holland, New York)

<u>Publications in Japanese</u>
Gekkan Computer Digest
JECC Computer Note
Joho Sangyo Benran
Joho Sangyo Shimbun
Joho Shori
Joho Shori Gakkai Ronbunshi
Nihon Joho Shimbun
Nihon Keisai Shimbun
Proceedings of the Information Processing Society of Japan (IPSJ)
Transactions of the Institute of Electronics and Communication Engineers (IECE)

<u>Organizations</u>
Dempa Publications
Japan Electronic Computer Company (JECC)
Joint Information Processing Development Center (JIPDEC), Tokyo
Ministry of International Trade and Industry (MITI), Tokyo

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introductory summary of the project in the keynote speech. Then three subcommittee chairmen reported overviews of their subcommittee's work: Hajime Karatsu of Matsushita Communication Industry on "Systemization Technology" (social needs and impacts), Kasuhiro Fuchi of ETL on "Basic Theory and Software Aspects," and Hideo Aiso of Keio University on "Computer Architectures." Finally, these research plans were presented in more detail by four speakers on each of the two main topics: theory and architecture. The speakers and titles of these lectures are shown in Appendix A, and the written version of each lecture is found in the proceedings of the conference, which was published by JIPDEC.

The remaining program of the conference consisted of six invited lectures given by foreign speakers and three panel discussions. The first invited lecture was given by E.A. Feigenbaum of Stanford University. He characterized fifth-generation systems as artificial intelligence (AI) machines or expert systems and stressed that the critical issues are software, not hardware, and acquisition and representation of knowledge, not logic itself. This lecture was an

interesting contrast to the following two invited lectures, which were logic-oriented: "Logical Program Synthesis" by W. Bibel of the Technical University of Munich (FRG) and "The Scope of Symbolic Computation" by G. Kahn of INRIA (France). The remaining three invited lectures were on architecture: B.H. McCormick of the University of Illinois spoke on a cognitive computer architecture based on biological models and VLSI hardware; P.C. Treleaven of the University of Newcastle-Upon-Tyne (UK) analyzed advantages and disadvantages of control flow, data flow, and reduction program organizations; and J. Allen of MIT spoke on algorithms, architecture, and VLSI technology.

Background of the FGCS Project

The FGCS project is the third information-processing-related "large project" in which MITI's ETL has played a central role as planner and coordinator. The two previous ones were the High-Performance project (1969-1970) and the Pattern Information Processing System (PIPS) project (1971-1980). These previous projects have more or less achieved their original targets, although there seem to exist differences of opinion among foreign observers as to whether PIPS was a success or not. Unlike these two previous projects and the VLSI project (which were also sponsored by MITI and which ended in 1980), the FGCS project seems to worry some Japanese industry executives because they see the project as grandiose and futuristic.

The FGCS project envisions computers with features to meet the various social needs expected in the 1990s. More specifically, the fifth-generation computers are referred to as knowledge information processing systems (KIPS) possessing such features as the following:

1. Facilities for natural language processing, picture and image processing, and speech understanding.
2. Intelligence capable of learning, associating, and inferring.
3. Multilingual translation.
4. Very high performance logical inference capabilities with a machine speed that is 10^2 to 10^4 times faster than today's super computers.
5. Capability to retrieve a knowledge base within a few seconds on main storage for 100 to 1000 GB.

The project will last for 10 years, which will be divided into three stages: the initial stage of three years, the intermediate stage of four years, and the final stage of three years. They plan to complete a prototype of the fifth-generation computer by 1990. The budget requested for 1982 is about $2.5 million, and the budget estimated for the first phase (1982-1984) will be $46 million. (According to some sources, including a recent article in Business Week (December 14, 1981, pp. 39-120), the total budget for FGCS over the period of 10 years is projected as high as $400 million.) However, it should be noted that a majority of people who engage in the project are government employees whose salaries are not counted in the budget since

they are paid from the regular budget. Mr. Okamatsu stated in a panel discussion session that they were negotiating with the Ministry of Finance for additional funds. As of this writing, Japan's Ministry of Finance has yet to approve any funding, and some committee members we met at the conference were concerned that the recent pressure to reduce the government spending might adversely affect the FGCS project.

It should be noted that the FGCS program is just one of several MITI-sponsored projects (see Appendix B). Others are (1) basic technology development of the next generation (fourth generation) computers with emphasis on software technology and peripherals; (2) R&D for high-speed scientific computers (the so-called "super computer project"); and (3) the optoelectronic integrated circuit project. Major computer manufacturers seem much more involved in these projects than in the FGCS, because of their near-term impact. For instance, Fujitsu, Hitachi, and NEC are all working on a Super-Cray machine that will be ready in 1983-1984. The ultimate target of the high-speed scientific computer project is 10 billion floating point operations (BFLOPS) according to the information we obtained at Hitachi, but this target, like that of FGCS, sounds overly ambitious. (See the section on the Hitachi Central Research Laboratory below.)

As for the FGCS project, the industry executives we met at Fujitsu and Hitachi said that they had not figured out specifically how to participate in the program, but their intention to cooperate in the project is unquestionable. The overall committee organization of the FGCS project, its members, and their affiliations are shown in Appendix C. Also, at the end of the FGCS conference proceedings, about 100 major contributors to the preliminary studies of the project are listed. Among them, the largest group of 15 researchers is from MITI's ETL, and one half of the FGCS lectures were delivered by people from ETL. There are also contributors from Japanese computer manufacturers such as Fujitsu, Hitachi, NEC, Toshida, Mitsubishi, Oki, Matsushita, and Sharp, as well as from NTT, JIPDEC, and various universities.

Research Themes of FGCS Project

The technical details of the FGCS project can be found in two publications given to the attendees at the conference: the proceedings of the FGCS conference and <u>Research Reports in Japan--A Collection of Recent Research Reports Related to the R&D of the FGCS</u> (both of which were published by JIPDEC), whose tables of contents are shown in Appendixes A and D, respectively. In addition to these publications written in English, the FGCS committee had earlier published seven volumes of reports in Japanese (2276 pages). They have made very thorough surveys of the state of the art of FGCS-related technologies (VLSI, new programming languages, data flow machines, relational data base, natural language understanding, machine translation, speech and image recognition, and so on). Many people, including us, doubt that in 10 years they can develop their dream system, which will be composed of "seeing, hearing, and speaking" computers equipped with common sense that will enable the systems to judge from memory (knowledge base) and solve new problems (inference and problem-solving capabilities).

To present an overall picture of this huge project, we will summarize below the proposed research and development themes. The FGCS committee has proposed 26 themes on which research and development will be carried out in the next several years. The themes are grouped into the following seven areas: (1) basic application systems, (2) basic software systems, (3) new advanced architecture, (4) distributed function architecture, (5) VLSI technology, (6) systematization technology, and (7) development supporting technology.

As basic application systems, they propose to develop the following six systems: (1-1) machine translation system, with 90 percent accuracy; (1-2) question-answering system, to be used for intelligent robots; (1-3) applied speech-understanding systems, such as a phonetic typewriter; (1-4) picture and image data storage and retrieval system; and (1-5) applied problem-solving system, having the ability to play the GO-game at the level of amateur grade 1.

As basic software systems, they propose to develop the following three systems: (2-1) knowledge base management system, with storage and retrieval of 20,000 rules and 10^8 data items (100 GB); (2-2) inference machine, which performs 10^2 to 10^3 megalogical inferences per second (note that one logical inference per second (LIPS) corresponds to 100 to 1000 instructions per second according to their estimate); and (2-3) intelligent inference system, to communicate with unspecified speakers in terminology used in one branch of science.

In the area of new advanced architecture, they propose to investigate the following six machines: (3-1) logic-programming machines, using PROLOG as a starting point; (3-2) functional machine (based on LISP, reduction, and data flow function machines), suitable for symbol manipulation and list processing; (3-3) relational algebra machine, to support the relational data base system, using 100 parallel processors; (3-4) abstract-data-type support machine, to modularize the vast and complex software; (3-5) data flow machine, to perform parallel processing using 10^3 to 10^4 processors and 10-GB memory, and with the final target performance, 10 billion instructions per second (BIPS); and (3-6) innovative von Neumann machine, using VLSI with 10 million transistors per chip. Note that in the above research topics, (3-1), (3-2), (3-4), and (3-5) are all closely related.

The area of distributed function architecture includes the following investigations and developments: (4-1) network architectures; (4-2) data base machine, with 1000-GB capacity and 10^4 transactions per second performance; (4-3) high-speed numerical computation machine, using 1000 processor elements to achieve 1 BFLOPS performance; and (4-4) high-level man-machine communication system, to handle about 4000 Chinese characters, 1000 words, and $10^4 \times 10^4$ dots for picture and image processing.

The area of VLSI technology includes investigation of the following types: (5-1) VLSI architecture, to make full use of VLSI with 10 million transistors per chip, which is expected to be available around 1990; and (5-2) intelligent VLSI computer-aided design (CAD) system, capable of storing architecture data base and design knowhow data base.

The area of systematization technology includes development of the following systems: (6-1) intelligent programming system, which is

capable of fetching subprograms from an algorithm bank (knowledge base) by user requirements, synthesizing a program, and verifying whether it meets the specified requirements in an optimum manner by a process of inference; and (6-2) data base and distributed data base systems.

As a developing support system, they propose to build a hardware environment called System 5G on which VLSI-CAD systems will run. The CAD systems will eventually become intelligent CAD systems that will acquire design knowhow and perform automatic design of VLSI chips. System 5G will consist of super inference machines and 5G communication networks. System 5G can be accessed through 5G personal computers (very high intelligence terminals) for VLSI-CAD and software development necessary for the FGCS project. System 5G is to be used for developing the FGCS, including inference machines. But System 5G needs super inference machines. This would seem to be a vicious circle, unless a "super inference machine" (part of the FGCS) can be built without the use of System 5G.

PROLOG Versus LISP in the FGCS Project

"PROLOG" and "Data Flow" are the technical terms that we heard most frequently during the presentations of the FGCS project. The word PROLOG is short for "Programming in Logic," and it was originally proposed by K. Kowalski at the 1974 International Federation of Information Processing (IFIP) Congress. It is a high-level programming language that seems suited to the representation and manipulation of knowledge. Most of the U.S. participants (except for language specialists) had barely heard of PROLOG prior to the conference. LISP is more or less a standard language for people working on artificial intelligence (AI) in the United States. Thus one question raised by many U.S. participants was "Why PROLOG, not LISP?" or "Why a logic programming language, not a conventional programming language?" Ko-ichi Furukawa of ETL answered this question as follows:

> PROLOG has all the features that pure LISP has, except for a lambda function. In addition, nondeterministic procedures are possible in PROLOG. Formal treatment and verification are easier in a logic programming language such as PROLOG. A logic language forces us to develop well-structured programs so that readability and modifiability should improve. However, it may be difficult to do intelligent optimizations so as to produce efficient programs on a logic programming language. On the other hand, logic expressions can contain a lot of parallelisms and thus may be suitable for data flow machines. It seems that there is a natural relation between PROLOG and data-flow computation.

(See "PROLOG and Data-Flow Computation Mechanism," by T. Yokoi of ETL, in JIPDEC's Research Reports in Japan--A Collection of Recent Research Reports Related to the R&D of the FGCS.)

Kazuhiro Fuchi of ETL stated that, "PROLOG is chosen as the starting point because PROLOG systems are considered capable of integrating all the good features of LISP systems, and since PROLOG is a programming language based on basic inference operations, PROLOG machines could represent the first step toward inference machines."

According to information presented at the conference, research in PROLOG has been primarily pursued in Europe, especially at the University of Edinburgh, Scotland, and at Marseilles University, France. J.F. Sowa of IBM Systems Research Institute (SRI) in New York City is also active in the field. A timely tutorial article by Ron Ferguson entitled "PROLOG--A Step Toward the Ultimate Computer Language," was recently published in the BYTE Magazine (November 1981, pp. 384-399).

Observations and Assessments of the FGCS Project

As was pointed out by Tohru Moto-oka and Hajime Karatsu in their lectures, there will be many impacts if the FGCS project is "successful." For example, the following changes are expected:

1. Computers that can be operated by natural languages will be much easier to use than today's computers. This will significantly broaden application areas. Therefore the number of people using computers will increase explosively.
2. Such computers will be helpful in enhancing productivity in the currently low-productivity sectors such as retail industries, public services, medical services, offices of white-collar workers, agriculture, fishery, and forestry.
3. The use of intelligent robots will spread over various manufacturing plants.
4. Multilingual translation machines will reduce the language barrier of the Japanese. This together with satellite communication and optical fiber techniques will help internationalization of Japan.
5. Japan has an opportunity to fulfill its international duty expected as an economic power by investing and taking a leadership role in a large-scale scientific project such as the FGCS.

The subject of international cooperation was brought up from time to time during the conference. For example, E.A. Feigenbaum, of Stanford University, said, "Significant international collaboration will be possible and useful in the development of fifth-generation systems. . . . A truly international effort will be necessary and a major international economic and social benefit will result." We gather from various discussions that the following statements from the proceedings of the FGCS conference represent the FGCS committee's position:

> For a number of reasons, it is difficult to make this an international project. Instead, it is desirable to execute it as a national project with Japan having the liberty to decide

> its course. It must be noted, however, that the project includes research on mechanical translation, mechanical interpretation, etc. which must be carried out hand-in-hand with other countries. In these fields, therefore, it will be found expedient to link the projects with similar projects abroad or arrange for joint studies.

During the panel discussions, two opposite views were expressed on the FGCS project: one view was that the scope of the project is too broad and the other view was that it is too narrow. The former opinion is expressed in statements such as, "The project must confront the reality and must focus on smaller topics. We cannot work on so many aspects. We do not have enough computer scientists. Being realistic is important." Proponents of the latter view point out that "there are neglected areas such as complexity theory, algorithm design, semantics, and biological approach."

B.H. McCormick, of Stanford University, viewed the FGCS's proposal as being made up of three principal subprojects, the 5G personal computer, 5G super computer, and 5G cognitive computer, and he said,

> In 25 years in the computer field, I have observed many super computer projects . . . . None of these projects remotely achieved its stated goals; all the systems they built were not commercially successful. Nonetheless, projects such as these built the early American supremacy of the computer industry. . . . I see the FGCS as a project to develop the technological base underlying knowledge systems.

Our observation is somewhat in line with McCormick's. Clearly, the goals set by the FGCS project are overly ambitious and optimistic. As a long-range national project, however, it is necessary and appropriate to set goals so high that no single company can afford working alone. If a project is so conservative that success is in sight, there is no need for a national project: it can be carried out within a company. In the FGCS project, some will succeed, some may fail. It is doubtful that they will produce commercially successful AI machines within 10 years. But that is not their purpose. The significance of the project will be the scientific by-products, or the basic technologies that may result from the nationwide efforts to make the project as successful as possible. These by-products will be helpful for improving productivity in many fields and will strengthen Japanese industry as a whole.

These accomplishments would certainly increase Japan's competitive position in a number of hardware and software products in future office automation, personal computer, distributed systems, and so on. An accurate assessment of the FGCS project will be to view it as a part of "Japan's strategy for the '80s" as described in a recent article in <u>Business Week</u> (December 14, 1981). Japanese scientists and engineers seem determined to prove themselves as innovators and to surpass the United States in this knowledge-intensive industry. The FGCS project together with other MITI-sponsored research programs (see Appendix B) will help young researchers in Japan gain confidence to become more innovative in the computer field.

Report on Visits to Research Laboratories and Universities in Japan

Introduction and Summary. In this section, we report on noteworthy findings from our postconference visits, which were arranged by the National Research Council through the ONR office in Tokyo. The first author had visited these institutions in 1971 and 1976 and was impressed this time by the changes that have been made and the progress that our Japanese colleagues have achieved since then. In 1970 and 1971, most major universities in Japan were opening new departments called "information engineering" or "information science" that were separate from the traditional electrical and electronics engineering departments. The university computer centers were primarily batch-oriented, and there were a relatively small number of terminals for time-sharing service. The curriculum at that time was dominated by information sciences (such as information and coding theory, signal processing, and pattern recognition), and very few courses were given on architecture, operating systems, software, artificial intelligence, and so on.

The situation has changed significantly in the past 5 to 10 years. The university curricula seem comparable to those of many U.S. universities, although they do not match such major universities as Stanford and MIT in breadth of subjects offered. At Tokyo, Kyoto, and Osaka universities, however, we found that many laboratories were well equipped with computing facilities, minicomputers and microcomputers. Experimental data flow machines have been implemented in several places, and there is an increasing level of activity in sophisticated pattern recognition, speech recognition, and language translation. Artificial intelligence is gaining popularity, although we did not see in Japan "expert systems" like those developed at Stanford University. We met several students working on topics related to LISP and PROLOG.

The industrial and government laboratories we visited were MITI's ETL, NTT's Yokosuka Laboratory, and the research laboratories of Hitachi, Fujitsu, and NEC. All these sites except for Hitachi's Central Research Laboratory are relatively new. Ten years ago, ETL was in a shabby building in downtown Tokyo and was about to launch the PIPS project. Now it occupies an impressive building in a serene environment of Tsukuba City, equipped with powerful computing facilties. NTT's Yokosuka Laboratory was established in 1972, and its modern gigantic building is as striking as that of Bell Laboratories in Holmdel or of the IBM Research Center in Yorktown, although it is smaller that these U.S. laboratories (it houses only 1000 employees).

At Fujitsu, Hitachi, and NEC, our Japanese colleagues were quite open in discussing their latest high-end machines such as FACOM M-380/382 and HITAC M-280H, which is under development. All three companies are working on Super-Cray computers, which will be ready in two to three years. Hitachi is working on a vector processor called HP-1 whose speed will be 250 MFLOPS. The MITI-sponsored super computer project is substantially more aggressive and is aiming at 10 BFLOPS.

Fujitsu is proud of its successful development of a new gallium-arsenide-(GaAs)-based transistor, HEMT (high electron mobility

transistor). There are several to a dozen people working on the Josephson junction in each of these laboratories as well as at ETL and NTT.

Personal computers are booming among computer hobbiests and small businesses. We heard that many short courses on personal computers are commercially available. Both MITI and Japanese computer manufacturers are placing significant emphasis on software development. At both Fujitsu and NEC we heard about their efforts on software design and management tools.

Electrotechnical Laboratory. The Electrotechnical Laboratory (ETL) is the largest national research organization in Japan specializing in electricity and electronics. Since its establishment in 1891, ETL has undergone a series of expansions and reorganizations to cope with the needs of rapid technological innovation. In 1948 it gave birth to the Electrical Communication Laboratory (Nippon Telegraph and Telephone Public Corporation), and the ETL became a part of the Agency of Industrial Science and Technology (AIST), which is under MITI.

ETL has 729 employees, of whom 566 are research staff. It is one of the nine research organizations (of 16) that have in recent years moved to Tsukuba to form the Tsukuba Research Center of AIST. Tsukuba is a new scientific and educational city located approximately 60 km (37 miles) from the center of Tokyo to the northeast and about 40 km northeast of the New Tokyo International Airport.

First we visited their impressive computer center. The new Research Information Processing System (RIPS), which was installed and became operational in December 1980, offers advanced computing services to the Tsukuba Research Center of AIST. It contains the following four subsystems:

1. Host computer, which is a FACOM M-200 (11.8 MIPS) with 16-MB main memory, 64-KB buffer, and 38-GB mass storage system.
2. Center work stations, which provide high-performance input-output devices. The work stations include batch and time-sharing system (TSS) work stations, Kanji displays (Fujitsu 6652A), high-performance and high-resolution graphic displays, computer-aided design (CAD) work stations, and so on.
3. Remote work stations and laboratory automation facilities.
4. Optical fiber communication network. It consists of three types of subnetworks: (a) looped data highways operating at 16.89 Mbits/s; (b) starlike dedicated network with the maximum data transmission rate of 1.5 MB/s; (c) video network, which allows remote access of a video film library. More than 500 data terminals are accommodated by the data highway, and approximately 50 minicomputers are planned to join the network. The three optical communication networks have an overall length of 360 km.

We then visited the Information Science Division, which has approximately 50 people and consists of six sections: bionics, pattern processing, speech processing, mathematical engineering, computer

vision, and machine inference. Kazuhiro Fuchi is the general manager of the Information Science Division. He also serves as chairman of the Subcommittee on Basic Theory for the FGCS project. R. Nakajima of the Pattern Processing Section showed us their work on synthetic speech and speech recognition, which is a continuation of the PIPS project that MITI sponsored in the 1970s. For speech recognition they use a vocal code model to be represented by 17 parameters. The system can recognize 23 phonemes and 80 to 90 syllables. Their goal is to have a dictionary of 3000 to 5000 words.

In the Semiconductor Device Section (which is in the Electronic Device Division), H. Hayashi explained their efforts to develop future elements of VLSI. As for the memory chip, their target is a nonvolatile memory chip of 10 Mbits, which may become an alternative to the magnetic bubble. As for logic elements, they are looking into the high-speed limits of metallic oxide semiconductor large-scale integration (MOSLSI). Hayashi said that 10 people were working in the Semiconductor Device Section. In addition, five to six people are working in GaAs research, and six people on the Josephson junction within ETL.

Hozumi Tanaka, who is manager of the Machine Inference Section and gave a presentation on "Intelligent Man-Machine Interface Mechanisms" at the FGCS conference, described their efforts in natural language understanding. The effort is directly related to machine translation and question-answering systems. He said that their effort to implement a syntactic parser was already five years old. A syntactic analysis parsing tree was created by using LINGOL of MIT, and the implementation language is standardized LISP, i.e., Utah's LISP.

Our overall impressions of ETL were as follows: The building and facilities (especially the computing center), as well as the serene surroundings, were quite impressive. The levels of technical expertise of the ETL people appear very high, although relatively few of them hold Ph.D.'s and they rarely publish papers in international journals. The number of researchers who are actually involved in the FGCS at ETL is 20 to 25. Unless they intimately coordinate their basic research efforts with those at universities and industries, they will not be able to attack all the important theoretical problems that are required for the development of FGCS.

Yokosuka Electrical Communication Laboratory of NTT. The Electrical Communication Laboratories (ECL) is the research arm of Nippon Telegraph and Telephone Public Corporation (NTT) and consists of the R&D Bureau, Musashino ECL (1800 people), Yokusuka ECL (1000 people), and Ibaraki ECL (200 people). Yokosuka ECL was established in 1972, and its activities include the following:

- data communication (data communication network, computer, and text processing),
- transmission (digital network, optical fiber, satellite communications, and mobile communication),
- video communication (facsimile, video conferencing, and video processing), and

• input-output equipment (telephone sets and input-output equipment for data, character, and speech).

The Data Communication Department under Iwao Toda developed NTT's network architecture DCNA, which resembles IBM's SNA. Toda was also the head of the DIPS project, which developed high-performance computers (DIPS I, DIPS II model 5, DIPS II model 25, and so on), software, and the data base for NTT's nationwide data communication system. In his department is a communicating word processor (CWP) that can perform functions such as drafting of documents, editing of image pattern input through a facsimile terminal, document storage, and text communication. Also under study are Kana-Kanji code conversion, Japanese text-editing processing, and Kanji-processing software.

Research and development efforts on optical fiber communication systems are being pursued by the ECL's three laboratories: Musashino is responsible for devices (optical source and detector); Ibaraki is responsible for fiber and cable, and Yokosuka is drawing up a total system. In the mid-October, NTT sent out a press release concerning a semiconductor laser for a 1.5-μ oscillator, where 1.5 μ is the wavelength with least propagation loss. As for satellite communication, they are working on the development of domestic satellite communication systems using the 30/20 GHZ band and DA-TDMA (demand assigned-time division multiple access) systems.

CAPTAIN is NTT's Viewdata, a video information service providing a text-editing system that is unique to Japanese markets. It is a facsimile-based text editing for handwritten documents: by adding special marks to the original documents by hand and inputting them into the facsimile terminal, a user can obtain an edited output as a facsimile output.

Speech recognition technology is applied to such areas as mail sorting at the post office and information and inquiry service in the banking business. As for speech synthesis, NTT has a patent dispute with Texas Instruments (TI) because PARCOR (partical correlation technique), which was developed by Dr. Itakura and others of ECL is used by TI in its product "Speak and Spell." (A number of Japanese companies including Hitachi, Mitsubishi, NEC, SANYO, Oki, General Instrument, and Matsushita are producing large-scale integration (LSI) implementation of Itakura's voice synthesis method.) An optical character reader (OCR) terminal has been developed by which handwritten alphanumerical, "Katakana," and special symbols can be read accurately. Recognition of Kanji (printed and handwritten) is still in the research stage. A new portable Kanji printer that prints at the speed of 15 characters per second has been developed, using the thermal printing method and an LSI mask-ROM (1 Mbit) for the generation of 3400 Kanji characters.

The Musashino ECL, which has a staff of about 1800, includes a division called the Fundamental Research Division. Dr. Yamashita from its Information Processing Research Department gave us a brief account of their activities. Activities include machine translation (eight people), data flow machine (nine people), data base machine (two people), LISP machine (two people), programming theory, data base

theory, and cryptography. In the machine translation group, a prototype system is under way based on the transfer method. It uses DEC 2020/TOPS using MATRIX language. According to Yamashita, similar efforts exist at Fujitsu, Kyoto University (Professor Makoto Nagao), and Kyushu University (Professor Tamachi). The data flow machine group started two years ago and is building a LISP machine. They are not considering the use of PROLOG yet. A data flow processor array system, EDDY, is being developed, which consists of 4 x 4 processing elements (two Z8001 each) and two broadcast line control units. This is used for analyzing the operational characteristics of the data-driven processor array system. As for research on data flow machines, some efforts exist at Oki, Gunma University (Professor Sowa), as well as at ETL, ECL, and the University of Tokyo.

The NTT group has quite a few entries in Research Reports in Japan--A Collection of Recent Research Reports Related to the R&D of the Fifth-Generation Computer Systems (see Appendix D).

Dr. Hanada, the head of the Software Engineering Department in the Data Processing Development Division at Yokosuka ECL, described the software design methodology used in DIPS (DIPS is NTT's standard information processing system). A documentation chart called HCD (hierarchical and compact description chart) has been developed by extending the HIPO flow chart of IBM. It is used for developing control programs, data base software, and language processors.

University of Tokyo

Electrical Engineering and Electronics Departments: Professor Hiroshi Miyakawa, a well-known information and coding theorist, gave us an overview of the Electrical Engineering (EE) Department, which has 10 chairs, and the Electronics Department, which has 6 chairs. Each chair consists of one professor, one associate professor, and two assistants. The two departments occupy the same building (the Electronics Department branched out from the EE Department in 1960), and for all practical purposes they are not distinguishable. There are 95 juniors and 95 seniors for the two departments combined. Their master's course (a two-year program) has the capacity of 48 students per year. The doctoral course (a program of three or more additional years after the master's course) has the capacity of 28, but the actual number of enrolled Ph.D. candidates is around 20 each year. About 25 to 30 percent of Ph.D. graduates will find university positions, and the rest will go to industrial and government laboratories.

There are a number of research projects related to data flow computation. Professor Minoru Akiyama and Mr. Yamashita (a second-year Ph.D. student) discussed the application of data flow computation to the telephone exchange system. They showed us their small prototype implementation called DATAFLEX-1. The hardware of the control section of DATAFLEX-1 is similar to "BASIC DFM" of MIT. ZILOG 80A and Intel 8086 are used as processor elements.

Associate Professor Tadao Saito, who is under Professor Hiroshi Inose (currently at Caltech as a visiting professor), gave us a

presentation on three topics: (1) computer communication (packet switching, protocol validation, and protocol standardization); (2) computer architecture (data flow machine); and (3) on-line library system. The last subject is sponsored by the Ministry of Education, and Inose is chairman of the committee of this project, called the "Scientific Information Center Project." It will connect 10 to 15 libraries (primarily science and literature) under the Ministry of Education using the "N-1 Network," which is a network that connects major national universities. The network protocol is similar to that of Advanced Research Projects Agency Network (ARPANET) (unlike systems network analysis (SNA)) in the sense that it has distributed control. Optical laser disks (10,000 pages per disk) will be used as a data base, and the system will become operational in three years. The data flow machine project of the Inose-Saito laboratory started four years ago, and it is called the distributed data driven computer (D^3C). They use LST 11/2 as processing units and arbitration network. Saito says the arbitration network is a bottleneck of the architecture. Three graduate students are working on the implementation, and their objective is to achieve a data flow of 100 Mbits/s.

Professor Tohru Moto-oka and Associate Professor Hidehiko Tanaka specialize primarily in computer architectures. Moto-oka is the chairman of the FGCS organizing committee, and Tanaka is also a key member and gave a presentation on "Preliminary Research on Data Flow Machines and Data Base Machines as the Basic Architecture of Fifth-Generation Computer Systems" at the conference. We saw a prototype implementation of a procedure level data flow machine called TOPSTAR. The system hardware is composed of two kinds of modules: PM (processing module) and CM (communication/control module). PM and CM correspond to a "transition" and a "place" in a Petri net, respectively, and they are both constructed with a Z-80 microprocessor, 16-KB memory, and peripheral LSIs such as interrupt controller (i 8259) and DMA controller (i 8257). In their current version, TOPSTAR-II, there are 16 PMs and 8 CMs. Each PM is connected to several (ranging from 5 to 8) CMs. They are currently working on several applications of this data flow machine, such as parallel merge-sort, simulation of logic circuits, and fault simulation.

Moto-oka and Tanaka have also developed a multimodule associative processor called DREAM-II. It is a special-purpose processor for pattern processing, which is connected to the host computer through a DMA channel. DREAM-II is a single instruction multiple data (SIMD) type processing of microprogram control and consists of four modules. Each module includes two-dimensional access memory, bit manipulation logic, and a high-speed microprocessor (AM 2901, a bit-slice microprocessor of American Micro Devices, Inc.). They are evaluating this associative processing system in several applications, such as hand-printed Kanji recognition and LSI mask-pattern testing. They are also developing a relational data base machine based on hash and sort, which allows efficient execution of relational algebra operations such as JOIN and PROJECTION and set operations.

Professor Hiroya Fujisaki's laboratory has 10 people. Seven people are working on speech, and three on language (translation). In the

speech area, the group is studying speech production (generation), speech synthesis, and speech perception. Speech perception is essentially what we call speech recognition, but Fujisaki says that recognition should be investigated by understanding the human psychology. In this respect, his approach seems different from the statistical approach taken by F. Jelinek et al. at IBM in Yorktown.

Fujisaki's speech recognition effort concentrates on acoustic processing and phonetic recognition. Fujisaki said that the sounds "b," "d," and "g" are difficult to distinguish. His recent method, which makes use of "transition rate" parameters, can recognize them with 95 percent accuracy, whereas no other groups have ever achieved accuracy greater than 90 percent.

Another approach to speech recognition uses syllable recognition. Japanese is somewhat easier to work with than English in this respect because it has only 200 or so syllables whereas English has about 1000 (partial) syllables. Fujisaki thinks that speech recognition in English will not be practical for another 10 years.

Information Science Department: This department is a spinoff of the Physics Department and belongs to the Faculty of Science. There are four chairs, and we met Professors Yamada, Kunii, and Gotoh. The department produces 4 Ph.D.'s, 8 M.S.'s, and 15 B.S.'s per year.

Professor Hisao Yamada described his efforts on a Kanji-input technique. In his scheme, each Kanji character is addressed by two strokes, and he claims that his machine is not much more difficult to learn than an English typewriter. A 400-hour training will allow a person to input 150 characters per minute, whereas any Kana-Kanji conversion technique will not do better than 100 characters per minute according to Yamada. He is very much interested in having the keyboard developed by Dick Hirsch, of the Human Factor Center of IBM San Jose.

Professor Toshiyasu Kunii is interested in data base and software engineering. He is no longer a member of the FGCS committee and is rather critical about the FGCS project on two counts. First, he says, "The FGCS effort conains nothing new. They are aggregating existing ideas and bundling them." Second, he points out that "they do not place much emphasis on software, and I believe that software product engineering is important."

Professor Eiichi Gotoh, who earned his fame as the inventor of parametron 25 years ago or so, is now heavily involved in LISP. His group wrote a LISP interpreter and compiler. His conclusion is "Never sort, but do hashing in main memory." He claims that HLISP, the LISP compiler that he developed, runs faster than that of the University of Utah. His machine is called FLATS (FORTRAN-LISP associative tree-hashing set), and it was built, interestingly enough, by Mitsui Engineering and Shipbuilding Co. The work was presented at the Sixth IEEE Annual Symposium on Computer Architecture in 1979. Gotoh has also worked on electron lithography. RIKEN and Japan Electronic Optics made his electron lithography machine, and ECL of NTT has bought one.

Computer Center of the University of Tokyo: The impressive Computer Center serves over 4000 researchers from many universities

located around the Tokyo area through the interuniversity computer network. The system consists of four loosely coupled subsystems, each of which is a tightly coupled dual processor of HITAC M-200H (10 MIPS per processor) with 16-MB storage, and thus the system contains a total of 8 units of M-200H and 64-MB main storage. There are 8 drums (16 MB each, 120 MB in total), for the TSS system, 96 spindles of 300-MB disks, and 32 spindles of 200-MB disks. Thus the total disk capacity is 36,880 MB. In addition, a MSS (mass storage system) with 706 magnetic tape cartridges (50 MB each, 35,000 MB in total) and 12 spindles of 200-MB staging disks are attached. Five data communication control processors, and three network processors allow 500 simultaneous terminal (TSS and remote job entry (RJE)) connections.

At the center, batch processing service is provided on a "do-it-yourself" basis, and the scheme is called advanced open-batch processing. Many color CRT displays are deployed for this purpose, and the following input-output equipment is provided: 7 card readers; 13 line printers, each with automatic paper cutter; 12 magnetic tape transports; 1 Kanji laser-beam printer/plotter (720 lines per minute cut sheets); and 1 floppy disk. As for picture- and image-processing systems, there are five graphic displays (one high-resolution display, three storage-scope displays, and one color graphic display), five Kanji displays and keyboards; three ink-jet Kanji printers; and six XY plotters.

A VAX-11/780 is also installed as a subsystem at the center. The operating system is UNIX (rather than VAX/VMS of Digital Equipment Corporation (DEC)), and this system is used for the research of software such as OS (the operating system of IBM), compiler, and editor. This VAX-11/780 subsystem can also operate as a remote batch station on TSS terminals of the HITAC M-200H main system.

FORTRAN 77 is the language used by more than 90 percent of the users, so the center has a large FORTRAN support software. Other available languages are BASIC, PASCAL, PL/I COBOL, APL, LISP, REDUCE (a formula manipulator), ALGOL 68, and RPG. This LISP compiler, called HLISP as developed by Gotoh's group, is one of the fastest LISP compilers employing hash techniques. The REDUCE runs under the HLISP. In addition, they have text editor and text-formulating editor. An information retrieval system called TOOL-IR on ORION is also available, and several data bases (primarily literature abstracts and indices) are accessible via TSS terminals.

This huge computer center is operated by 41 people, and there are 13 people (including two associate professors) for research and development tasks.

According to Gotoh, Hitachi is expected to deliver a Super-Cray machine to this computing center by 1983.

Kyoto University

Department of Information Science: The department was founded in 1970 and consists of six chairs: information science fundamentals (Professor Toshiyuki Sakai); logic circuits and automata (Professor

Shuzo Yajima, Associate Professor Yahiko Kambayashi); computer systems (Professor Hirosl i Hagiwara, Associate Professor Shinji Tomita); computer software (Professor Takao Tsuda, Associate Professor Masashi Shimasaki); information systems engineering (Professor Yutaka Ohno). Each year 40 students are admitted to the undergraduate program, 18 students to the master's program, and several to the doctoral program.

Professor Sakai's laboratory has approximately 20 people including two assistants (Ph.D.'s), 2 Ph.D. students, 9 M.S. students, and 5 visiting researchers. The laboratory is divided into three groups: (1) automatic speech processing; (2) picture processing and image understanding; and (3) document understanding. Yasuo Ariki, an assistant, described a spoken word recognizer (implemented by Matsushita) that can recognize isolated Japanese words spoken by unspecified speakers. The recognition algorithm is based on two-step recognition: phoneme recognition (using reference patterns) followed by word recognition (using a word dictionary). It operates satisfactorily in real time for 10 numerals and 32 city names. In experiments the system achieved 94.3 percent recognition rate for 5 males and 93.3 percent for 5 females according to their report. This prototype system was exhibited at "PORTOPIA" held at Kobe this summer. Michihiko Minou, a Ph.D. student, demonstrated their storage and retrieval system for Japanese documents. This specific system is designed to handle digitized visiting cards. Retrieval of a visiting card is requested either by the character code or by handwritten characters. In both cases, key parameters are extracted from these patterns, and the most likely visiting card is selected by the pattern matching method. The correct retrieval rate is 78 percent in their experiments involving 615 visiting cards stored, when an inquiry is done in character codes, which are then translated into character patterns. Kosaka Inagaki, an assistant, showed us a parallel processing sytem MACSYM for fast document processing. The system contains 4 (expandable up to 17) Z8001 16-bit microprocessors with 128-KB local memory and shared memory of 8 Mbits (maximum 14 Mbits). A newspaper layout understanding system is built on MACSYM. A newspaper image is fed into the system via a digital facsimile (COPIX 9700 by Toshiba). A news item designated by location is then extracted by using the newspaper layout rule; the headline is normalized in size; background patterns are suppressed; and the text is reconstructed line by line. The processed image is suited for further editing or information retrieval by matching keywords in headlines.

Professor Yutaka Ohno's group is working on (1) concurrent LISP, which is a concurrent programming language based on LISP, and a multi-microprocessor for it; (2) a multi-microprocessor system for three-dimensional color graphics; and (3) a data base management system (DBMS) for a composite type of distributed data base. He is also investigating functional programming language from the standpoint of software design. Ohno will be the general chairman of the Sixth International Conference on Software Engineering to be held in Tokyo in September 1982. (Dr. Koji Kobayashi, the chairman of NEC, is the honorary chairman of the conference.)

Professor Hiroshi Hagiwara and Associate Professor Shinji Tomita work on computer systems and architecture. A microprogrammable

computer, GA-1, has four homogeneous arithmetic and logical units (ALUs), suitable for low-level parallel processing and for such applications as image processing, real time animation, and language processing (BASIC, APL, LISP, and PASCAL). The next version, GA-2, is under development (by 10 people for two years) and will be operational in March 1982. It is a user-microprogrammable computer, and its processing power and microprogram productivity will be an order of magnitude higher than those of GA-1. Its software will be in PL/I.

Professor Shuji Doshita's group works on (1) complexity theory related to Horn sets; (2) machine translation, and (3) a knowledge base approach to document retrieval. The first subject is concerned with whether the unsatisfiability for a Horn set in the propositional logic can be decided by unit or input resolution in deterministic polynomial time. The second subject is concerned with their attempt to construct an English-Japanese machine translation system via formal semantic representation based on Montague Grammar. (Montague Grammar is a linguistic theory originated by Richard Montague in 1974.) Toyoaki Nishidera, a Ph.D. student and assistant, showed us their prototype implementation of a machine translation system based on PANAFACOM U200. The program is written in LISP. Doshita and his group, although they are not officially affiliated with the FGCS committee, were quite familiar with PROLOG as well. Overall, we were quite impressed by the depth and breadth of the work being done in this laboratory.

Computing Center of Kyoto University: The computing center has four CPUs of FACOM M200, with main storage of 48 MB. The operating system is multiple virtual storage (MVS). The center is connected through the N-1 network (a packet switching network of NTT) to Tokyo and six other major national universities. More than 1500 batch jobs per day are handled here, and 180 TSS users are serviced. About 30 percent of the workload is from nearby universities and colleges that are connected to this center. Hagiwara said that FACOM M382 will come here in 1982 or 1983.

Other Departments: In parallel with the Department of Information Science discussed above, there is the School of Electrical Engineering, which consists of three departments: the Department of Electrical Engineering (which has been in existence since 1898), the Department of Electronics (since 1954), and the Department of Electrical Engineering II (since 1961). Together they admit 120 undergraduate students each year and 85 master's students. Professor Makoto Nagao, who is a committee member of FGCS, belongs to the Department of Electrical Engineering II. Unfortunately, he was out of town, but we met his assistant professor, Takashi Matsuyama, and Jun-ichi Nakamura, a Ph.D. student. Their current research topics include (1) pattern recognition and picture processing, and (2) mechanical processing of natural languages (i.e., machine translation). They have implemented two machine translation systems. One is for translating from English to Japanese the titles of scientific and technical articles, and it is written in PL/I. The system has been transferred to ETL of Tsukuba. The other system, currently under development, will translate computer manuals written in Japanese into English.

Professor Toshiharu Hasegawa is in the Department of Applied Mathematics and Physics and holds the chair in logic systems. His current research areas encompass (1) on-board processing and scheduling in communication satellites, (2) system theoretic approaches to transporation systems, (3) queueing network theory and its application to communication networks. The satellite project is a joint research with KDD and is aiming at on-board processing satellites, which will become available in the 1990s. Professor Hasegawa is involved in the traffic control project, which uses fiber optics of 35 km between Osaka and Kobe.

Osaka University, Toyonaka Campus

Department of Information and Computer Sciences: The department was established in 1970, and there are six chairs: fundamentals of information and computer sciences (Professor Kokichi Tanaka, Associate Professor Shin-ichi Tamura); logic design and automation theory (Professor Tadao Kasami, Associate Professor Ken-ichi Taniguchi); computer languages (Professor Nobuki Tokura, Assistant Professor Toshio Araki); information processing machines (Professor Makoto Kizawa, Associate Professor Jun-ich Toyoda); analysis of information systems (Professor Toshio Fujisawa, Associate Professor Susumu Matoba); and computer organization (Professor Kensuke Takashima, Associate Professor Hideaki Miyahara). The department admits 40 undergraduate students every year.

Professor Tanaka's laboratory covers pattern recognition, artificial intelligence, and knowledge engineering, and we were given demonstrations of several prototype implementations: (1) an image-processing system for medical applications, such as (a) three-dimensional display based on serial tomograms and (b) automatic assembly of eye fundus photographs using blood vessel structures; (2) image input and output devices using a two-dimensional charge-coupled device (CCD). Image processing such as filtering is done by Intel 8085.

In the area of artificial intelligence, Professor Tanaka's group is working on a data structure for knowledge representation, called μ-factor, and is applying the scheme to question-answering systems and image interpretation systems. A LISP version of μ-factor was created for implementation on FACOM 230/45.5 (256 KB). They are also working on a Kanji input-output system for Japanese word-processing applications.

Professor Tadao Kasami, who is internationally known for his earlier work on algebraic coding theory, is now interested in cryptography as well as in multiuser coding theory. His associate professor, Ken-ichi Taniguchi, will soon be visiting the University of California at Berkeley to work with Professor Michael Harrison. Mr. Sugiyama, an assistant, is interested in an algebraic specification language and its applications. Another assistant, Mr. Ito, is interested in theoretical problems of relational data bases and is investigating how to handle dependency between attributes. He seems familiar with the work of Ron Fagin of IBM's San Jose Laboratory.

According to Kasami, there were no activities related to languages for data flow machines. Some students are using the interpreter for the simple functional programming language that was designed by John Backus.

Professor Toshio Fujisawa, a well-known network theorist, is now interested in the computational complexity aspect of layout problems (for PCB, LSI) and placement and wiring. He is also working on the problem of analyzing a large analog circuit that involves a linear equation $AX = y$, where A is a larger sparse matrix. He is familiar with the work of Bob Brayton of IBM Yorktown. Toshio Matsuura, an assistant, is using multi-microsystems for software-related work. One is PANAFACOM PFL-16A, for which he and his student designed and implemented a floppy disk controller and color CRT interface. The OS is a single-user version of control program for microprocessor (CP/M), and Unix-type file structure is used.

Professor Kensuke Takashima was recently appointed professor: he was previously a departmental director of NTT's Yokosuka Laboratory. Takashima is planning to start a data base machine project, but he has not acquired a staff yet. Associate Professor Miyahara recently joined the department from Kyoto University. He is implementing a multi-microprocessor for simulating queueing network models. Z80s are used to represent nodes, and Fujitsu 1400 for statistical analysis. He is also planning to develop a local network of the Ethernet type using fiber optics (a similar effort exists at Tsukuba, called GAMMA NET, for which Professor Ebihara of Tsukuba University is the principal investigator). In order to provide "multi-access and broadcast channel" characteristics, a device called a star-coupler will be used. The idea is to provide cross-talks between optical fibers that are coupled by this device. According to Miyahara, NEC has developed a product that couples 8 fibers, and Toshiba is developing a star-coupler for 100 fibers.

Department of Control Engineering: Professor Saburo Tsuji came to the university from ETL about 10 years ago and is well known for his long-term involvement in robotics. Tsuji says that robotics research in Japan has been quite successful in technology transfer in the past 10 years. The use of welding robots is an example. The recent robotic research is concerned with the development of assembly robots and robots with vision inspection capability. The latter will be used for semiconductor production (vision for wire-bonding, inspection of regular patterns on masks and wafers) and inspection of PCB in computer manufacturing. As for robot languages, Tsuji thinks that the United States is more advanced than Japan. Examples are Stanford R and MIT Assembly analysis. According to Tsuji, the Mechanical Engineering Laboratory of MITI in Tsukuba City is working on robots that assist handicapped people, such as a robot that raises a patient's bed. Tsuji is actively involved in vision-related research. He referred us to an article on "Industrial Computer Vision in Japan" that appeared in Computer (published by IEEE), May 1980, pp. 50-62.

Fujitsu Laboratories, Ltd. Hiroshi Yamada, the director, was our host. Tatsuo Miyakawa, the manager of the Information Processing Laboratory, and Kenichi Miura, a senior engineer in the Development Division, provided English translations of Yamada's talk. Yamada gave us a brief introduction to Fujitsu and its laboratories. Fujitsu has now established several joint ventures and subsidiaries in the United States including Amdahl Corp., TRW-Fujitsu, Inc. (established in May 1980), American Telecommunications, Inc., at Anaheim, and Fujitsu Microelectronics, Inc., in San Diego (established in 1979). The company's overall productivity has doubled betwen 1977 and 1981. One of Fujitsu's achievements during the past year was the introduction of the world's first high-electron-mobility transistor (HEMT), which is a new type of transistor based on GaAs technology. They have achieved the switching delay time of 17 ps (picoseconds) per gate, which compares favorably with the top speeds of the Josephson junction. It is approximately 30 times faster than a conventional metallic oxide semiconductor field effect transistor (MOSFET).

Fujitsu Laboratories, Ltd., is a wholly owned subsidiary of Fujitsu Limited. It has 850 employees and eight divisions: research, integrated communications, computer systems, semiconductors, component technology, materials, medical engineering, and Kansai R&D center. Several AI-related activities exist: machine translation (using a semantic network as the intermediate representation), a handwritten character recognition method (an algorithm called "stroke position matrix method"); and a speaker-independent isolated word recognition system (which accepts telephone quality speed input, based on phonetic analysis and pattern matching). Bubble memories, plasma displays, HEMT, Josephson junction, and optical devices were mentioned as research issues.

Dr. Yamada then expressed his personal opinion about the FGCS project. MITI's plan on FGCS is not definite yet, and Fujitsu has not yet decided on how to deal with the FGCS project. In Yamada's view, the objectives are vague, whereas MITI-sponsored projects in the past had clear targets, such as MIPS figures. Although MITI officials are asking for international cooperation, they do not seem to know how to handle it because they have had no previous experience. Despite all these uncertainties, it is certain that Fujitsu will participate in FGCS, but specific details had not yet been determined. During the 1990s, the biggest problem will be software, but the FGCS plan does not provide a clear view of this problem, Yamada says. Fujitsu is interested in artificial intelligence because a solution to the software bottleneck problem may be found there. Their emphasis is on machine translation and intelligent robots. (There is a small effort in data flow machines at Fujitsu, related to control of robots.) Fujitsu does not have enough experience to make any comments on LISP versus PROLOG and on whether data flow machines are proper hardware or not.

We then took a tour of the plant where FACOM M-380/382, Fujitsu's largest machine, is assembled. It was announced in May 1981, and its first customer shipment will be in early 1982. The M-380 uses high-speed LSI logic chips (400 and 1300 logic gates per chip and 350-ps

gate propagation delay, as compared with 1 ns (nanosecond) for the IBM high-speed RAM (3081) with access time of 5.5 ns). High-density multichip carriers (MCC) and their horizontal stacking design improve the M-380's internal speed. An approximately one-foot-square MCC can accommodate up to 121 LSI logic and RAM chips. The power consumption is 28 kVA, and air cooling is used. It has three levels of storage hierarchy: 64-MB local buffer, 256-KB global buffer storage, and 64-MB main storage. Its clock time is 16 ns, and they claim that the M-380 is 50 percent faster than the IBM 3081. Its multiprocessor version M-382 can have a 128-MB main memory.

Several technical presentations were given by research staff members: Masayashi Tezuka of the Advanced Software Section discussed their relational data base system called RDB/VI, which consists of an interactive subsystem for relational query (ISRQ), a data storage and control subsystem (DSCS), and an application subsystem. Its query language RDB/QL is similar to SQL. A software called PLANNER has been developed on RDB/VI by incorporating a geographical information subsystem (giving the population of different age groups, and so on). A demonstration of PLANNER on FACOM M-200 was later given to us. It has color graphic display support, and a Japanese language support is planned.

S. Uchida talked about the machine translation system called ATLAS/U. They adopted the transfer approach rather than the pivot approach. The key strategies of ATLAS/U are (1) to adopt a conceptual network as a representation of the intermediate level, (2) to emphasize semantic analysis, (3) to select syntax and words by pattern matching and expression rules, and (4) to learn by examples. Five people worked for two years on ATLAS/U. The ATLAS/U is used for computer manual translation from Japanese to English. It uses Kana-Kanji conversion for the Japanese input, and its limitation is the size of the dictionary. The current version contains 10,000 Japanese words and 40,000 English words. We also saw their speech recognition system. It requires a 0.6-s pause between phrases and handles 1000 words (256 B per word). A handwritten character recognition system uses feature extraction techniques by projecting patterns to different directions, line densities, and so on.

Other noteworthy items discussed or shown in the exhibit room were as follows: a GaAs field effect transistor (FET) amplifier (5.9 to 6.4 GHz) was developed to replace the traveling wave tube (TWT). A large-capacity disk drive called Eagle I (F6421), which has 446-MB capacity and 1.859-Mbit/s data rate and is comparable to the IBM 3380. Its first customer shipment is in 1983. Its enhanced version, Eagle II (F6425), will be available in 1984. Magnetic bubble memory for 1-Mbit devices is under development. A bubble microcomputer is being considered. As for very high speed switching devices, Josephson GaAs and HEMT are being pursued by five to six people in each area.

Fujitsu established in 1973 the International Institute for Advanced Study of Social Information Science (IIAS-SIS) with Tosio Kitagawa (professor emeritus of applied mathematics at Kyushu University) as its director. In April 1980, it moved from Kamata, Tokyo, to a new independent building inside the Numazu Complex of

Fujitsu. It appears to be a very academic group of 30 people or so and is divided into six groups: fundamental informatics, information science, computer science, system science, mathematical science, and physical science. They appointed Professor R. Bellman (mathematics), Professor E.R. Caianiello (environmental science), and many other foreign scholars as visiting fellows. According to their brochure, Professor Raymond Yeh, of the University of Maryland, also serves as a counselor. We did not visit the institute, but Kaname Kobayashi, of this institute, gave a presentation, "Program Design Transformation," which discussed the specification language, design language, and implementation language from the knowledge engineering viewpoint.

Lastly, M. Sugimoto of the Development Engineering Department, Development Division, gave a talk, "Software Diagram Description--To Increase Software Productivity." The staff of IIAS-SIS developed a software design tool called the Fujitsu essential software diagram description (FESDD) as a means for software documentation (for both design specification and implemental specification) and as tools for supporting the top-down design and implementation. He touched on PROLOG, although it seems to have no direct bearing on FESDD.

Hitachi Central Research Laboratory. The Hitachi Central Research Laboratory, situated in the peaceful surroundings of Kokubunji, a suburb of Tokyo, was founded in 1942. It has 800 research members, 160 of whom have doctorates, and 350 support people. It is one of six corporate laboratories. The others are Hitachi Research Laboratory (1260 people), Mechanical Research Laboratory (550), Engineering Research Laboratory (250), Production Research Laboratory (420), and System Development Laboratory (280). In addition, there are division laboratories (Consumer Product Research Center, Design Center, and Device Development Center). Of the 74,000 Hitachi employees, 8,000 are in R&D (5,000 in plants and divisions and 3,000 in the laboratories). R&D expenditures for Hitachi are $600 million per year (5.9 percent of sales), and expenditures for the Central Research Laboratory are $60 million per year. Of the research budget, 45.3 percent is for "independent research" and the remaining 54.7 percent is for "sponsored research" (45.7 percent from plants and business groups, 8 percent from subsidiary companies, and 4 percent from the government).

Hisashi Horikoshi, manager of the Eighth Department, was our host. He told us that computer manufacturers do not have much involvement in FGCS, although K. Torii of Hitachi is on the Architecture Subcommittee. Hitachi does not have many FGCS-related activities yet, although a language translation effort exists. However, another MITI project, the super computer project under Dr. Kashiwagi of ETL, involves heavily the six major computer companies (Fujitsu, Hitachi, NEC, Mitsubishi, Toshiba, and Oki). The major research target of the super computer project is technologies such as GaAs and Josephson junction, and Hitachi, Fujitsu, and NEC as well as ETL are working on these technologies.

We were then taken to various laboratories. Mr. Suzuki discussed their efforts on magnetic bubbles. A 1-Mbit chip has now been

transferred to the product division (16- to 64-Kbit chips have already been used for NTT's ESS). This 1-Mbit chip will be used for numerical control (NC). A 4-Mbit bubble card is now planned as the next project. Its potential applications include point of sale, processing computer, office computers, acoustic equipment, and portable systems.

In the robotics laboratory, Mr. Ejiri gave us a brief account of the history of Hitachi robots: a prototype intelligent robot called Hivip Mrk 1 (1970); a compact packaging robot, HI-T-Hand Mrk 2 (1972); a precision inserting robot, Hi-T-Hand Expert-2 (1973), an electro-motor assembly robot, Expert-5 (1975), and so on. He also showed us a vacuum cleaner assembler robot and a nuclear reactor inspection robot.

About 50 industrial robots are sold per month. Hitachi's competitors are Kawaski-Juko (strong in large robots) and Tateishi Company. As for the robotics in Japan, Ejiri referred us to a survey paper written by S. Tsuji of Osaka University that appeared in Computer (see the section on Osaka University).

We were also shown a demonstration of a TSS-based document-editing system, called TPS/II. An A4-size sheet (typically 1000 characters) requires 2 hours for Kana input, and 30 minutes for Kana-Kanji conversion. (Professor Yamada's system at the University of Tokyo will operate 2 to 3 times faster after operators are trained.) The system seems too slow for any practical use and has the homonym problem in the Kana-Kanji conversion. A sentence in the demonstration had the word "shocho" as the subject of the sentence, which is supposed to mean "head of institute (or research center)." But the Kanji that appeared on the screen after Kana-Kanji conversion was a homonym, "head of police (or fire) station." The operator rejected this word, hit a key, and got another homonym, "first menstruation." She promptly hit the key again and finally got the right word, "head of institute."

A computer network (HINET) that connects the Central Research Laboratory and Musashino Laboratory (1.2 km away) is using fiber optics with a data rate of 20 Mbits/s. In VLSI design, they are working on complementary metallic oxide semiconductor (CMOS) chips with 20 K gates with automatic placement and wiring. They use hie rchical structure, where a block (basic unit of logic) contains 500 tc 00 gates.

They are also working on a verification program for logical-to-physical checking. They also talked about a CMOS master slice with 6 K gates, where an automatic placement and wiring program (maze-running algorithm) is used.

They then told us about a high-end machine, the HITAC M-280H. It will have 12 to 17 MIPS and use pipelining and buffer LSI (4 Kbits, 5.5 ns), logic LSI (1500 gates, 0.5 ns), and main memory LSI (65 KB, access time 150 ns).

As for the vector processor and vector compiler, they discussed HAP-1 (Hitachi array processor, type 1). Its speed is 250 MFLOPS, as compared with Cray-1 (170 MFLOPS), FACOM 23/75 AP (25 MFLOPS), and HITAC M-280H-IAP (integrated array processor) (35 MFLOPS). They said that MITI's national project has the goal of 10 BFLOPS. MITI plans to deliver its super machine in 1988, whereas HAP-1 will be delivered in 1983. They started the HAP project two years ago with five or six

people, and now about 40 people are engaged in this development effort. Of these, 20 are logic designers (about 10 experienced designers and 10 new people), and the remaining 20 include assistants (for drawing), secretaries, and so on. Packaging is designed by another group.

NEC (Nippon Electric Company) Central Research Laboratories. The R&D organization of NEC underwent an extensive reorganization in July 1980 and divided to form the Research and Development Group and the Production Engineering Development Group. The former handles basic technology research, and the latter, production technology and productivity. The Research and Development Group consists of the Basic Technology Research Laboratory (300 people), the C&C Systems Research Laboratories (200 people), the Optoelectronics Research Laboratory (70 people), the Software Product Engineering Laboratory (50 people), and the Resources and Environment Protection Laboratory (40 people). The phrase "C&C" was coined by NEC to signify their commitment to the integration of "computer and communications." The C&C Systems Research Laboratories include the Communication Research Laboratory, the Computer Systems Research Laboratory, the Application System Research Laboratory, the Peripheral Equipment Research Laboratory, and the Home Electronics Research Laboratory.

Our hosts were Yukio Mizuno, the associate senior vice president, Koji Nezu, the assistant general manager, and Sohei Misaki and Shuji Nakada, all of the Software Product Engineering Laboratory. According to them, NEC has approximately 10,000 people engaged in software development: the number includes those at software companies that are NEC's subsidiaries. They briefly discussed their software development maintenance system (SDMS). It is an integrated software development system and has been used at several departments within NEC. SDMS has five subsystems: the project management subsystem, the design subsystem, the programming subsystem, the test subsystem, and the product management subsystem.

They then talked about a new system construction model that unifies control-flow-based modularization techniques (a la N. Wirth and D. Parnas) and data-flow-based modularization techniques (a la M.A. Jackson and J.P. Morrison). The modularization is intended to allow stepwise comprehension of the complex system and the development of the modules to proceed in parallel. The new model combines control-flow-based techniques (in which modules are connected by module call relations) and data-flow-based techniques (in which modules are connected by their input-output data streams). The design methodology and tools based on this model are incorporated in a subsystem of SDMS, and have been used extensively by 10 projects. COBOL and FORTRAN do not have features to realize the structure defined by the model; therefore a tool has been developed to add these features to COBOL and FORTRAN. They presented the work at COMPCON 81, held in Washington, D.C., on September 15-17, 1981.

A discussion of software quality control (SWQC) followed. Software quality features include functionality, acceptability, performance,

modifiability, and reliability. The prime vehicle of SWQC is the "QC circle," where programmers expose their mistakes to their colleagues, with no management involved. Specific tools of SWQC are data sorting-stratification, control chart, Pareto's chart, and cause and effect diagram.

After these technical presentations, we were taken to an exhibit room where we saw, among other things, their speech recognition device, DP-100. It can recognize spoken words of limited vocabulary. Applications of such a primitive speech recognition system include baggage or parcel sorting, simulation for air traffic control, and voice-assisted input for CAD. Another interesting prototype in the exhibit room was a fingerprint viewer.

At the end of our visit we had a luncheon meeting with Michiyuki Uenohara, the senior vice president and director of research. Uenohara used to be on the technical staff of Bell Laboratories, where he was involved in research on parametric amplifiers. Unlike some of the other executives we met at Fujitsu and Hitachi, Uenohara was quite positive and supportive about the objective and significance of the FGCS project.

Dewar's Report on Trip to Japan

I arrived in Japan the week before the FGCS conference and so was able to attend the meeting of the Information Processing Society of Japan (IPSJ) at the University of Tokyo and to meet informally with some Japanese computer scientists, many of whom were involved in the FGCS work.

Since nearly all university faculty and students were at the IPSJ meeting, I was able to meet, briefly at least, with many university professors. More extensive meetings were arranged with the following: Professor E. Goto, chairman of the Information Science Department at the University of Tokyo (the inventor of parametron), now working on the FLATS (LISP based) machine and not directly involved in FGCS work; Professor Akinori Yonezawa, Tokyo Institute of Technology (who received his Ph.D. from MIT with Professor Hewitt), working on specification of the data base management system (DBMS); Professor Katayama, Tokyo Institute of Technology, working on hierarchical functional programming (HFP), a language based on attribute grammars; Professor Izumi Kimura, Tokyo Institute of Technology, working in the area of software engineering and text editing (the latter being a much more significant field in Japan due to character set and language problems); Koichi Furukawa, Electrotechnical Laboratory (ETL), one of the main workers in the PROLOG aspect of FGCS; and Reiji Nakajima, University of Kyoto, working on the IOTA language. In addition, I met with Professors Yoneda and Wada from the University of Tokyo, who are colleagues in the International Federation of Information Processing (IFIP) working group 2.1 (the programming languages working group, of which I am chairman).

As requested by the Computer Science and Technology Board, I discussed the issue of translation of Japanese technical materials with the university people I met. At least among the academic contacts,

there was remarkably unanimous agreement that there were no materials of academic interest beyond those published in the major journals of IPSJ and of the Institute of Electronics and Communication Engineers (IECE). Furthermore, both societies publish part of their work in English. For example, Goto's last three papers have been published in the English-language version of the Proceedings of the IPSJ journal, which appears quarterly and carries, in addition to papers from Japanese computer scientists (one must be an IPSJ member to publish), English-language abstracts of all papers recently published in the society's Japanese-language journals.

Interestingly, although several hundred ACM members in Japan receive Communications of the Association for Computing Machinery (ACM) and other ACM journals, fewer than 20 U.S. scientists, including Japanese residents, are IPSJ members receiving IPSJ journals. Even including library subscriptions, fewer than 80 copies of the English-language Proceedings of the IPSJ journal are received in the United States.

The single most important step that could be taken to increase knowledge of Japanese work would be to promote and encourage access to this journal in the United States. The papers in it represent a useful cross section of current work, and the translated abstracts provide thorough coverage. Of course, as is the case in the United States, the academic journals do not fully cover the hardware manufacturing field, but nevertheless it is significant that the Japanese computer scientists I talked to believed it would be a waste of time to look beyond the major journals. Unlike some major industrial concerns in Japan, the academic community is eager to have its work better known in the United States, so I take these judgments at face value. I should note that not all articles are from universities. In one sample copy I received, there was a long article by workers at Hitachi, on VM implementation, which clearly reflected ongoing work of commercial relevance, and which I found to be most informative.

Since I had heard that there had been discussions between ACM and IPSJ on joint membership plans, I arranged a meeting with Masumi Sakamoto, the secretary general of IPSJ. It seems that both sides are favorably disposed to the idea, but bureaucratic problems, particularly on the Japanese side, where the directorship changes each year, have so far delayed any real progress. Such an arrangement would be highly desirable, and ways to encourage ACM to pursue this possibility should be investigated.

I also visited the University of Tokyo Computer Center. This is an impressive installation, built around eight top-of-the-line Hitachi models (approximately 200 MIPS of general purpose computing power) with 128 MB of fast main memory and an amazing array of peripherals. This machine is freely available for use by academic computer scientists, in contrast to the situation at most U.S. universities, where meaningful efforts to provide high-capability computing have generally been abandoned. This discrepancy is helping Japan to close what might be called the "software gap." With very few exceptions, the computing environments at U.S. universities tend to be hostile to major software projects. The commitment to avoid this situation in Japan is evident.

I was quite disappointed with the FGCS conference itself on two counts. First, the project seems to be grounded in the uncritical acceptance of a number of pragmatically dubious, avant-garde computer science concepts, including functional programming in general and PROLOG in particular, data flow machines, object-based architectures, relational data base machines, and advanced AI concepts. Of course, all these areas represent challenging research fields, which are in fact quite well represented in U.S. universities. However, it is my opinion, and one that I found to be shared by nearly all the Western computer scientists present, that the MITI commitment to this risky research line for a high-technology, industry-based project is premature and that what is needed instead is a great deal of fundamental research, in which Japan has not been as successful as in pure technology.

This concern is shared by a number of Japanese academic computer scientists, who, although no doubt more enthusiastic than I concerning the technical directions that Japan has chosen to emphasize, are nevertheless concerned that there is no good mechanism for causing MITI funds to flow into advanced university research. In his address, Professor E.A. Feigenbaum of Stanford University, although naturally enthusiastic over the basic AI direction, warned that this had to be regarded as an area requiring substantial basic research and, within the bounds of decorum, ridiculed the premature commitment to PROLOG as the central language.

The second aspect of my disappointment was that the presentations were glossy, general talks complete with fancy slides, no doubt well suited for discussions with high-level funding agents, but remarkably devoid of technical content. All attempts to obtain specific information by direct questions were deflected. Either the project is even more vague than it appears, or there is a definite desire to avoid specific technical information interchange. Computer scientists with whom I spoke directly, however, seemed open and eager to exchange information.

I do not believe that the software and systems aspects of this MITI project are destined to be successful unless major changes of direction occur, which currently seems unlikely. However, it should be noted that the hardware aspect (e.g., building super personal computers) will almost certainly succeed. To the extent that MITI FGCS funds are committed in this direction, Japan's enormous potential in this area will be further increased as will the competition they provide to U.S. industry.

CONCLUSIONS

1. U.S. computer scientists need more information on computer science and technology in Japan.

2. Much information on Japanese computer science and technology is available in English, but it is not readily accessible to most U.S. computer scientists.

3. Some translation of Japanese papers in computer science is needed on a continuing, albeit selected, basis. Of highest priority is

the translation of Joho Shori Gakkai Ronbunshi and Section D of the Transactions of the Institute of Electronics and Communication Engineers (about 150 pages per month). Of next priority is Section C of the Transactions (about 50 pages per month) and the proceedings of the conferences of the IPSJ and the IECE (600-900 pages per year). Of lower priority, but still worth continuing, is the translation of the special interest group newsletters (800-1600 pages per month). A possible alternative to translation might be the annual publication of a directory of Japanese computer science researchers and research projects.

RECOMMENDATIONS

1. Continued translation of selected Japanese journals, theses, and books should be established under U.S. government sponsorship. Titles and abstracts of translated materials should be published in Computing Reviews (or an equivalent journal). These translations should be economically viable after a few years of government sponsorship.

2. A program should be established to send selected Japanese-speaking computer scientists in this country to Japan as guest workers. An intensive language program for a few specialists who do not speak Japanese could be included. Such a program could be funded by some existing private organization such as the American Federation of Information Processing Scientists or the Association for Computing Machinery, or it could be funded by the U.S. government.

3. Academic centers of expertise on Japanese computing should be established in the United States or in Japan. U.S. government funding should be provided to support these centers in the continuing review and analysis of Japanese activities and (possibly) in the activities recommended above. These centers should be encouraged to interact with Japanese organizations such as the Japan Information Processing Development Center (JIPDEC), the Information Technology Promotion Agency (IPA), MITI's Electrotechnical Laboratory (ETL), and various other governmental and industrial centers of computer expertise. The existence of these centers should be advertised in U.S. computer journals, and American computer scientists should be encouraged to use the facilities. Institutions that are known to have strong programs in both computer science and East Asian studies and that therefore would be well-suited to host such centers include Stanford University, Harvard University, and the University of Hawaii.

Chapter 2

DEVELOPMENTS IN WESTERN EUROPE

The situation in the Western European countries with respect to the availability of computer science information is different from that in Japan in two significant ways. First, there is generally good communication between American and Western European computer scientists, and, second, the American scientist can read most of the important research results in English.

In the past, there has always been good communication between American and Western European computer scientists. For example, Algol 60 was developed in the early 1960s by an international committee of thirteen that included three or four Americans, as well as people from France, Germany, England, Switzerland, and the Netherlands. Many American computer scientists have close ties with European scientists and institutions and have spent a year or two in Europe. Further, a fair number of Europeans have American Ph.D.'s and tend to maintain their ties to the United States. The better U.S. universities and research laboratories usually have at least one European visitor in computer sciences each year, and often more. The American conferences on theory of computation, principles of programming languages, and so on, are well attended by Europeans. In addition, the major research journals, such as the Journal of the Association for Computing Machinery (ACM), SIAM Journal on Computing, Software Practice and Experience, and Acta Informatica, have international editorial boards.

The International Federation for Information Processing (IFIP) provides a formal means for fostering communication, as explained in Chapter 6. The working group meetings and conferences promote international understanding, encourage joint research, and disseminate research ideas before they reach the publication stage. A number of international workshops in Europe, some sponsored by NATO, have also stimulated communication.

Personal contact is one of the best ways to make research ideas more widely known. However, effective cooperation necessitates direct contact and travel. Support of such travel by appropriate funding agencies is critical to maintain and improve the ability of American computer scientists to benefit from European resources.

Of course, not every computer scientist has close ties to Europe, and to some extent all scientists must rely on the literature to discover what is happening elsewhere. Fortunately, English is close to

being the language of publication and communication for European computer scientists, perhaps partly to foster communication among themselves. A majority of them have traveled in the United States or England and can converse fluently in English, and almost all can read and write English. English is the official language of many European computer science conferences. Further, publishers such as North Holland, Springer, and Prentice Hall are international and publish many works of European authors in English.

This is not to say that all work is done in English. Some results go unnoticed because they are not in English. But, by and large, the important work finds its way into English, and, if it does not, at least it is in one of the European languages, which are more understandable to U.S. scientists than, say, Russian or Japanese.

SURVEY OF IMPORTANT JOURNALS

As a first attempt at producing quantitative information on research available in English, a list was made of all articles published in eleven journals (see Table 2-1 for a list of the journals) and in the Springer Verlag Lecture Notes Series. The list included the title of the article, the author(s), and his or her country. An article with two authors from different countries was listed twice. This list is given by author's country in Appendix E and by source in Appendix F.

This is a representative set of journals, ranging in areas covered from theoretical computer science to practical software to hardware. It contains American journals (e.g., *Communications of the ACM*) as well as those published in foreign countries (e.g., Acta Informatica and Information Processing Letters).

Of about 720 articles appearing in these journals in 1980, about 325 of these were written by people in countries other than the United States. Only seven articles were written in a foreign language. Thirty-three countries, including most of the Western European countries, are represented. The countries represented most heavily are the United States (393), England (48), Canada (47), Germany (47), France (27), the Netherlands (25), Israel (20), Japan (19), and Italy (15).

Such statistics tend to confirm our opinion that, in general, the Western European computer scientists do want to publish in English, and in the well-known, respected journals.

SURVEY OF SOME EUROPEAN CONFERENCES

As in the United States, a number of conferences, workshops, and advanced courses are held in Western Europe each year. To determine the extent of American participation in these conferences and the availability of the research, the proceedings of eight conferences held in 1980 were surveyed. All these proceedings appeared in the Springer Verlag Lecture Note Series (Springer Verlag is primarily a German publisher). Appendix G contains a list of the conferences surveyed.

TABLE 2-1 Sources of Information on Computing in Western Europe and Other Countries

Acta Informatica	Theoretical Computer Science
Communications of the Association for Computing Machinery	Transactions on Programming Languages (TOPLAS)
Information Processing Letters	Institute of Electrical and Electronics Engineers Transactions on Computers
Journal of the Association for Computing Machinery	Institute of Electrical and Electronics Engineers Transactions on Software Engineering
Mathematics and Computers in Simulation	
SIAM Journal on Computing	
Software Practice and Experience	

The conference topics ranged from data bases to programming to semantics to computer-aided design. They were held in five different countries (Italy, France, Germany, the Netherlands, and Denmark). About one third of the papers were given by Americans (61 of 198), and only three papers were not given in English. Thus it seems that in order to promote communication among themselves, Europeans turn to English.

CONCLUSIONS

1. Since most Western European computer scientists speak English fluently and tend to publish in English, no new translation facilities are necessary.
2. Personal contacts between American and Western European computer scientists are very important in the dissemination of research ideas, and should be stimulated.

RECOMMENDATIONS

1. No extra translation facilities are needed.
2. A formal survey, organized by scientific area and covering important work in all Western European countries, would help to make existing materials more accessible and more widely known. The possible role of IFIP working groups in this endeavor should be explored.
3. Personal contacts and travel should be stimulated by increasing and making more readily available foreign travel funds.

Chapter 3

DEVELOPMENTS IN EASTERN EUROPE AND THE USSR

The literature review made to assess developments in Eastern Europe and the USSR involved the following countries: Bulgaria, Czechoslovakia, German Democratic Republic, Hungary, Poland, Rumania, and the Union of Soviet Socialist Republics (USSR). These countries are part of the Council for Mutual Economic Assistance, usually abbreviated as COMECON, CMEA, or CEMA in the Western literature. The other COMECON member nations, Cuba and Outer Mongolia, were not included here. The primary objective of the review was to search for publications that cover developments relating to computer science within these countries. The review focuses almost entirely on the USSR due to its dominance in the field.

The majority of the theoretical articles from Russia and Eastern Europe come from journals published by the academic community. These are sent to the Association for Computing Machinery (ACM). The ACM publishes the monthly Computing Reviews, which contains abstracts from approximately 420 periodicals. Fourteen of these are Soviet journals in, or closely related to, computer science and are included as cover-to-cover translations into English. These fourteen publications include the most important Soviet computer science literature (see Appendix H). The Soviets' knowledge that these periodicals are translated encourages the Soviet academic community to make them their first choice for publishing papers. The time that passes from the publication of the Russian original until the publication of the English translation is about eight months on the average, and varies from six months to one year. This should be regarded as good service, since the delays in the publication of the original are often greater.

In these periodicals there are few articles by authors living outside the Soviet Union. Eastern European authors tend to publish in the journals of their own country. If an article is published outside the native country, there seems to be a greater effort to publish in a Western journal, in English, than to publish in a Soviet journal.

In addition to identifying the Soviet journals received by Computing Reviews, we scanned available material since 1975 through the System Development Corporation's (SDC) search service. Many of the 475 resulting abstracts deal with typical developmental problems, rather than theoretical discussions. It is not known what percentage of these abstracts might also appear in translated journals listed in Appendix H.

A simple test was devised to identify and quantify the number of references to COMECON authors in Western computer science and mathematical papers. It was assumed that the number of COMECON authors cited in various papers would provide an indication of the degree to which their material is being read. For this purpose, twelve issues of the Communications of the ACM from the period 1979 to 1981 were selected. No Soviet or Eastern European authors were among the 1203 references in these issues.

It would be ineffective at this time to translate more journals from the COMECON countries, since the material already being translated into English is not being used by Western computer scientists.

In the field of mathematics, the Soviets have an excellent reputation, and American authors make far better use of their work. An issue of the Transactions of the American Mathematical Society (volume 261, 1980) was taken as a sample. Of its 30 papers, 9 referenced one or more Soviet papers. Of the total of 473 references, 11 were to Soviet papers.

If it is not the language barrier that prevents Westerners from being acquainted with the work of the Soviet and Eastern European computer scientists, what is it? The general political condition in the Soviet Union, and in the Eastern European countries to a lesser extent, prevents technical people from attending conferences and seminars. This restriction inhibits the development of personal relations, which is essential for a successful exchange of ideas. Other reasons might also be suggested for the lack of references to Soviet work. For example, there may be too much emphasis on theory to be of interest to Westerners, or the mass of available Western material may be considered higher-priority reading. In any case, the American computer science community needs to become more aware of the material that is available, instead of increasing the amount of translation at this time.

One problem experienced in this literature search was how to determine what was available when no prior knowledge of a specific article or journal existed. That is why the general electronic scan of material was made through a library that used the System Development Corporation's search service. This service maintains approximately 50 different data bases, which cover all areas of science and technology, social science, and business. A search used the following criteria: (1) COMECON countries and China, (2) material since 1975, (3) any language, and (4) abstract keys such as computer science, data processing, hardware, and software.

The search was conducted on four data bases with the following results: For the NTIS data base, the number of hits was 256; for COMPENDEX, 44; for ELCOM, 39; and for INSPEC, 136; for a total of 475. These abstracts fill 295 pages; the total search-and-print cost averaged 25¢ per abstract. No attempt was made to determine the percentage of duplication or of irrelevant articles located due to an inappropriate selection of search keys. The search costs are reasonable and allow one to identify material quickly from many sources that is unavailable in the printed library indexes. If the data bases were greatly expanded to encompass the computer science citations of

foreign countries, a significant part of the literature search problem would be solved. It is encouraging to report that there may be an automated retrieval system in the Soviet Union.

Frank Columbus, of Plenum Publishing Company, provided some interesting information regarding document translation, the availability of material, and the market potential of translated journals. Plenum currently translates more than 30 Soviet books and more than 90 Soviet journals annually. It was emphasized that availability of information is not a problem and that a Russian data base with technical citations exists.

The greatest problem is the lack of demand for the translated product. Recent budget constraints have caused cutbacks in the funds allocated to public, corporate, and academic libraries. The first thing libraries cut back on or eliminate is foreign subscriptions and translations. The two main factors they consider are cost, which is significantly higher for translated material, and usage.

The advantage of locating material by using an automated search is that specific articles can be located easily without the library's having to purchase the books or journals. In addition, the search software system usually maintains informative statistics on the nature of the inquiries and selection counts for the citations. By not translating the articles, or by translating only an abstract, a more current and extensive file of citations can be maintained. The problem of translating still exists, but the volume of translation can be significantly reduced. Only articles that met the search criteria of the inquirer and had abstracts confirming that interest would need to be translated.

It is recommended that additional discussions be held with Plenum Publishing Company, other interested publishers, and library search services to gain more information about the possibilities of obtaining access to foreign literature data files. A qualified organization could describe the process of verifying the availability of foreign search services, obtaining the data files, integrating them into existing search services, obtaining citation updates and maintenance, and obtaining the source material. The cost and time frame involved with the above tasks could thus be identified.

Among the abstracts obtained from SDC's search service, a reference was found to a cooperative effort among the COMECON members regarding a scientific and technical information system. The citation is included as Figure 3-1.

Abstract creation and translation are easier when tables of contents for foreign journals are given both in Russian and in English, as in Figures 3-2 and 3-3. All other parts of this particular journal are in Russian. In some cases, the table of contents may serve as a substitute for an abstract if the titles are sufficiently descriptive.

Implementation of a system of automated search and selective translation would greatly help in deciding which material would be translated first, since the final user would make that evaluation. Sources of translators include Agrew Tech-Tran, Inc., 21050 Erwin Street, P.O. Box 789, Woodland Hills, California 91365; and Linguistic Systems, 116 Bishop Richard Allen Drive, Cambridge, Massachusetts 02139.

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ACCESSION NUMBER	196566C
TITLE	Methods and Prospects for Developing an Information System in the Polish People's Republic in 1976-1980
AUTHORS	Derentovich, M.
ORGANIZATIONAL SOURCE	Polish People's Republic
SOURCE	NAUCHNO-TEKNICH. INFO., SER. 1, MOSCOW, No. 4, 1977, pp. 22-26.
LANGUAGE	Russian
ABSTRACT	In this article are discussed the future extension of the Polish Information Service and the formation of a Scientific, Technical, and Organizational Information System (SNTOI) with a view toward incorporation of this system in the International System of Scientific and Technical Information (MSNTI) in cooperation with member countries of CEMA, including the USSR, GDR, CSSR, and the Hungarian People's Republic. Emphasis is on the type of documents and information the system will handle and on the need for computer hardware, specifically YeS-series computers, and microfilming equipment.

FIGURE 3-1 Citation from Electronics and Computers (ELCOM) found by using SDC's international search service.

The estimated charges for translating Russian and East European text are from 18¢ to 24¢ per translated English word (all words), depending on the language and volume involved. This could result in a cost of approximately $40 per page. The American Mathematical Society (AMS) and commercial publishers have lists of free-lance translators, who charge significantly less; the AMS has obtained translations for $9 per page. Another source is the American Council for Immigrants and Professionals in New York. It must be emphasized that professional knowledge of the computer industry is necessary in addition to basic translating skills.

Although additional translation appears unnecessary over the short term, the journals listed in Table 3-1 may be future candidates. The computer science content of these journals is estimated at 20 percent or less. Entry 6 is interesting because it is a special issue on the Ryad 1055M.

It is difficult to determine the status of the computer science industry in countries where most material is very general or theoretical, as it is in Eastern Europe and the USSR. Detailed manuals regarding hardware and software products are not available. There could be a significant difference between what is written and what actually exists, especially if readers interpret foreign materials in terms of American computer systems background. Therefore one must monitor commercial developments in order to gain a more accurate view

АКАДЕМИЯ НАУК СССР
ЦЕНТРАЛЬНЫЙ ЭКОНОМИКО-МАТЕМАТИЧЕСКИЙ ИНСТИТУТ

ЭКОНОМИКА И МАТЕМАТИЧЕСКИЕ МЕТОДЫ

Основан в 1965 году
Выходит 6 раз в год
МОСКВА

Том XIV, Выпуск 6
НОЯБРЬ—ДЕКАБРЬ, 1978

СОДЕРЖАНИЕ

FIGURE 3-2 Source journal cover.

USSR ACADEMY OF SCIENCES
CENTRAL ECONOMIC MATHEMATICAL INSTITUTE

ECONOMICS AND MATHEMATICAL METHODS

Founded in 1965
Yearly 6 Issues
Moscow

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FIGURE 3-3 Translated source journal cover.

TABLE 3-1 Untranslated Journals from Eastern Europe and the USSR That are Future Candidates for Translation

Journal	Comments	Country
1. "Doklady Akademii Nauk SSSR, seriya Kibernetika i Teoriya Regulirovania" (Proceedings of the Academy of Sciences of the USSR, section Cybernetics and Control Theory), Izdatel'stvo "Nauka," Moskow	There is no translation of this section. Not every issue of the "Doklady" contains this section.	USSR
2. "Problemy Upravlenia i Teoriyi Informatsii" (Problems of Control and Information Theory), Academies of Sciences of USSR, Hungary, and Czechoslovakia	*Some articles are given* in English or with the English translation. Distributed by Pergamon Press.	USSR
3. "Izvestia Akademii Nauk SSSR, seriya Tekhniches-kaya Kibernetika" (Tech-nical Cybernetics), Izdatel'stvo "Nauka," Moskow		USSR
4. "Iskustvennii Intellekt i Roboti" (Artificial Intelligence and Robots)		USSR
5. "Teoriya Avtomatov i Vitchislitel'nie Systemi" (Automata Theory and Computers)		USSR
6. "Rechentechnik Datenverarbeitung" (Computer Technology Data Processing) Verlag die Wirtschaft, Berlin		GDR

of what is actually available. It is recommended that representatives of the American computer science community attend the Leipzig and Bruno Trade Fairs to identify new products and trends. In addition, it is recommended that a more extensive effort be made to evaluate in depth the state of computer science in the COMECON countries and to forecast more accurately what will happen over the next five years.

CONCLUSIONS

1. Translations of Russian materials in computer science are adequate, but the translated material is apparently ignored.
2. No additional effort to translate Soviet periodicals is necessary at this time.
3. The materials available from the Soviet Union reflect the progress in theory rather than advances in application and hardware.
4. Eastern Europe and the USSR will continue to show interest in representative technology from the Western computer industry.
5. Standardization of U.S. federal input-output specifications may increase compatability with Eastern European peripherals.
6. Attendance at Eastern European trade fairs is necessary to observe trends.

RECOMMENDATIONS

1. American scientists should be alerted to the fact that they probably underuse Soviet computer science material available in English.
2. The review of present computer science material from the USSR and the identification of the most promising or interesting articles may be useful.
3. Attendance at the Leipzig and the Bruno Trade Fairs, as well as at those in Hannover and Moscow, should be encouraged, to identify new products and trends in Eastern Europe.
4. The status of the USSR automated data base of technical literature and the feasibility of transferring this data base to some U.S. library search system should be examined.

Chapter 4

DEVELOPMENTS IN LATIN AMERICA

The state of computer science research and the quality of technical publications in 15 Latin American countries (Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, Guatemala, Mexico, Panama, Peru, Uruguay, and Venezuela) were reviewed. Personal contacts as well as Ulrich's International Periodicals Directory (published by R.R. Bowker, 19th edition, 1980) were used as the primary information sources. Discussions with key foreign technologists were helpful in refining the data further.

The search identified nine technical publications related to computer science. Colombia and Brazil have three each; Cuba, Mexico, and Peru have one each. The titles of the individual publications and related details are given in Appendix I. These nine publications focus on four subject areas: (1) systems engineering with an emphasis on local user group interests; (2) industry news; (3) review of industry trends, including translations of English-language articles from Datamation; and (4) journalistic (low technical content) reportage on national projects.

None of the publications seems to have a tradition of attracting seminal papers of significant interest to the U.S. scholarly community. Serious Latin American researchers prefer to publish in English, in U.S. journals, to reach more of their peers. A second type of significant technical literature is the proceedings of international conferences taking place in Latin America. They are usually published in English and are widely available to the U.S. scholarly community.

A selected list of centers of competence in computing in Brazil follows:

1. Federal University of Rio de Janeiro (systems engineering, operations/research, computational complexity, microelectronics);
2. Catholic Pontifical University, Rio de Janeiro (data base, electrical engineering, automation theory);
3. UNICAMP, Sao Paulo (laser technology, software engineering);
4. Pure and Applied Mathematics Institute;
5. Econometrics (EMBRAPA) Institute;
6. IBICIT (Brazilian Institute of Technical Information).

CONCLUSIONS

1. Much of the research reflects the fact that the R&D establishments are in a build-up phase.
2. There are several centers of excellence in computer science.
3. Major progress in computer science is not expected for the next 'hree to five years.
4. Mathematical programming and operations research expertise are more prevalent that traditional computer sciences, reflecting the close relationship to European informatics.

RECOMMENDATIONS

1. The current quality of the Latin American computer science-engineering literature warrants merely an ad hoc translation effort.
2. There are emerging centers of competence in computer science, particularly in Brazil, whose technical output might merit translation in three to five years.

Chapter 5

DEVELOPMENTS IN THE PEOPLE'S REPUBLIC OF CHINA

The purposes of the study on developments in the People's Republic of China are as follows: (1) to identify sources of information on computer science in the People's Republic of China that are available to the United States; (2) to determine the adequacy of these information sources, in terms of their capabilities to provide timely and valuable information; and (3) to make recommendations regarding ways to improve our understanding of China's computer science.

More than 100 articles and books, most of them published after 1977, were consulted in the course of preparing this chapter. However, the subject area is so vast that we have probably succeeded in accessing only a small portion of the total relevant information. Thus we do not claim that the following is a complete picture of computer science developments in China; it is merely a first step toward a systematic study of the topic.

We have identified 11 information sources that collectively provide an excellent picture of Chinese computer science developments.

1. Several national organizations are involved in exchanges with China. They are as follows:
   - The Committee on Scholarly Communication with the People's Republic of China (CSCPRC), a focal point for academic and scholarly exchanges with China since 1972. The committee is sponsored by the American Council of Learned Societies, the National Academy of Sciences, and the Social Science Research Council. It coordinates U.S.-China scholar exchange programs and publishes the China Exchange Newsletter, which contains timely information on exchange activities, academic activities in China, a bibliography on China, and so on. It also keeps a small but interesting library of references on China.
   - The National Council for U.S.-China Trade. The trade council produces a bimonthly publication titled The China Business Review and various reports that often contain valuable information on China's computer science education, research, and industry (for example, see reference (13) in Appendix J). The directory of research institutes in China (36) published in 1978 is particularly useful for general background on

China's scientific research and on their computer science before 1978. A useful companion to the directory is another publication of the trade council, this one on China's professional societies (8).

- The National Committee on U.S.-China Relations (NCUSCR). In addition to conducting exchange programs, the committee provides a wide range of information and advisory services on exchanges with China. The committee also publishes a newsletter, Notes from the National Committee. The committee-sponsored delegates publish trip reports.

For additional information, see (29).

2. Information on Chinese computer science is available from several U.S. government agencies:

- Joint Publications Research Service (JPRS). JPRS publications contain information primarily from foreign newspapers, periodicals, and books as well as information from news agency transmissions and broadcasts. One of the JPRS journals, China Report: Science and Technology, includes up-to-date information on China's computer science and technology, as well as on Chinese scientists and scientific organizations.
- National Technical Information Service. NTIS distributes JPRS publications and People's Republic of China Scientific Abstracts in agriculture; economic affairs; plant and installation data; political, sociological, and military affairs; and science and technology.
- National Foreign Assessment Center, Central Intelligence Agency. The center publishes reports and directories concerning China, such as (14).
- Science attaches at U.S. missions in China. Science attaches will respond to specific requests for information and/or assistance.

3. One of the most effective ways to gather information is through the use of computer-readable on-line data base retrieval systems, which are now accessible by almost all major libraries. Much of the information for this chapter was obtained from the data base systems DIALOG and PTS PREDALERT.

4. Many American libraries have extensive Chinese collections (40) including useful directories (for example, (35)) and Chinese journals. Through journal exchange programs, some of these libraries, such as the Stanford Hoover Library, are able to acquire journals published by various Chinese universities and research organizations that are usually not available outside China.

5. University centers for Asian studies are another source of information. At Stanford University, the Northeast Asia-United States Forum on International Policy carries out multidisciplinary research on such topics as the interface between the social sciences and technology. As an example, one student in the program is currently doing research on the impact of computers on the Chinese society of the future.

6. Published and unpublished trip reports by individuals and delegations who have visited China are an important source of information about China. The CSCPRC library houses many such reports. In addition, Columbia University has a collection of trip reports in its China Documentation Center. In the area of computer science, there have been a number of informative trip reports, including (1), (2), (3), (11), (17), (19), (21), (22), (30), (34).

7. Computer companies and translating services also can provide information on China:

- Chinese Science and Technology (CST). This journal contains unabridged translations of documents from China on its contemporary developments in science and technology.
- China Translation Printing Services (CTPS). This business firm, appointed by Chinese authorities, provides translation and publishing services in science and technology. It publishes US-China Electronics, a document produced in Chinese by the Chinese Fourth Ministry of Machine Building.
- Asian Computer Monthly, published by Computer Publication, Ltd.

8. Journals, magazines, and newspapers in computers and electronics often cover news on China's computer science and technology. Relevant items can routinely be found in publications such as Electronic Business, Electronics Weekly, Computerworld, Electronic News, Computer Weekly, Electronics, Mini-Micro Systems, Computer Data, and Computing.

9. Many American computer companies do business with China, and their marketing divisions can be very knowledgeable on China's computer industry. Companies that have done substantial business with China include IBM, Honeywell, Wang, Hewlett-Packard, and Sperry Univac. A new bimonthly magazine, China Computerworld, covers the People's Republic of China's growing computer market.

10. More than 5000 Chinese students and scholars are now in the United States; it has been estimated that 10 to 15 percent of them specialize in computer-science-related subjects. Chinese delegations also attend most of the major computer conferences abroad, although at this time only a small percentage of them deliver papers.

11. Research organizations in foreign countries are still another source of information on Chinese computer science:

- Research Policy Institute on Science and Development in Developing Countries, University of Lund, Sweden.
- International Development Research Centre, Ottawa, Canada.
- Organization for Economic Cooperation and Development (OECD) Centre, Paris.
- Science Policy Research Unit, University of Sussex, England.

Unfortunately, these information sources have some serious limitations:

1. None of the sources is specific enough to give details about China's computer technology and research. Most results cited are too

superficial to be useful to a computer scientist who is interested in technical information.

2. Chinese computer articles and technical reports are not being translated into English. Only a small percentage of abstracts are being translated by JPRS. In addition, the Chinese almost never publish articles in foreign journals.

3. Important computer conferences in China are not being reported. For example, the following two conferences held recently in China appear to have been significant, but we have little information about them: The National Conference on Exchange of Minicomputer Techniques was held in Xi'an, Shaanxi Province, in November 1979. Some 40 papers were delivered at the meeting, and more than 60 products were displayed, illustrating China's initial achievements in minicomputer circuitry. The National Conference on Integrated Circuits and Silicon Materials was held during January 1980, in Fuzhou, Fujian Province. Some 500 scientists and specialists attended the conference, where 209 papers were read. The participants also discussed possible solutions to problems of low production, poor reliability, and high prices of China's integrated circuits.

Currently, China's computer industry is capable of producing a 5 million operation per second computer and 8-bit single-chip microprocessors. It is estimated that they have about 2000 computers of more than 30 different types. If the current rate of growth continues, 5000 computers could be operational by the end of 1985. Most large systems are imported; the two most popular domestic minicomputers are comparable to Digital Equipment Corporation's PDP 11 and Data General's Nova.

It is generally believed that China is about 10 years behind the United States in processing speed and semiconductor technology, and about 15 years behind in software and peripheral equipment. China is, however, making a concerted effort to catch up.

At China's first National Science Conference, held in March 1978, computer science and technology was selected, along with other important areas such as energy and agriculture, to be one of the eight sectors that would receive China's major attention in the eight-year national plan for the development of science. In particular, the solution of scientific and technical problems in the production of large-scale and very large scale integrated circuits is given heavy emphasis. The plan calls for China to turn out giant computers and build a fair-sized modern computer industry by 1985. Within the next several years, rapid advances are expected in research on computer science, including computer software and applied mathematics.

The emphasis on catching up quickly in the computer field rather than on becoming profitable has meant that there are incentives for trying innovative schemes. In fact, it has been common among Chinese universities and research institutions to build computers for their own use, resulting in many different types of computers. Therefore there is a good chance that Chinese computer scientists may discover and experience techniques that have not been tried in the United States. It is important for us to watch the developments closely,

perhaps by forming a Chinese computer science clearinghouse organization under the auspices of one of the organizations mentioned above. Such a clearinghouse could serve as a center for the collection and translation of detailed information on Chinese computer science, and for the convenient dissemination of this information to U.S. computer scientists. The importance of creating such an organization will grow rapidly as Chinese computer scientists begin to catch up with the West.

CONCLUSIONS

1. Interactions between Chinese and American computer scientists are limited in number, involving sabbatical visits or excursions.
2. The Cultural Revolution set back computer science development in China from 10 to 20 years.
3. Almost no scientific papers by Chinese authors have appeared in publications outside of China.
4. Chinese computer scientists are extensively studying foreign computer science, and U.S. literature is readily available to them.
5. Chinese computer scientists are capable of doing original and first-rate work, as exemplified by studies on semantics and programming languages.
6. The Chinese have strong motivations to advance computer science because it can positively contribute to export and balance of trade.
7. Considering the developments that have taken place in the last few years, China is expected to make significant progress in this decade.

RECOMMENDATIONS

1. Little of the current literature appears worthy of complete translation.
2. U.S. computer scientists should be kept informed by title or abstract about existing and future publications, whether in Chinese or English.
3. Systematic publication of abstracts and reviews of important Chinese technical journals is recommended.

Chapter 6

THE ROLE OF THE INTERNATIONAL FEDERATION FOR INFORMATION PROCESSING IN INFORMATION INTERCHANGE IN COMPUTER SCIENCE

The International Federation for Information Processing (IFIP) is an organization dedicated to the interchange of information among member countries in the general areas of data processing, informatics, and computer science. The membership of IFIP includes countries from all five geographic areas examined in this report (the People's Republic of China recently became a full member of IFIP).

The activities of IFIP provide an important means for computer scientists in the United States to interact with their counterparts in other countries. As has been noted in other chapters of this report, the availability of English-language material, though vitally necessary, is not by itself sufficient. A high level of direct interaction, including personal contacts, is important, particularly because the field is moving so rapidly that much published material is out of date when it finally appears in print, a phenomenon even more true for translated material.

The scientific activities of IFIP fall into three categories:

1. Working group (WG) meetings. The working groups of IFIP are small groups (10 to 30 members) of international experts in specific fields. For example, WG 2.1 is concerned with programming languages, and WG 2.3 with programming methodology. These groups hold semiannual or annual meetings in member countries, which are attended by members and possibly some observers. Current work in progress is discussed. Sometimes, but not always, the work lends itself to cooperative research projects, and those outputs may be released as IFIP products. The WG membership elects new members on the basis of interest, geographical distribution, and demonstrated capability. Since much of the work of the WGs is highly informal and interactive, no formal papers are given and no formal proceedings of WG meetings are published.

2. Working conferences. Working conferences, typically organized by one or more WGs, are small technical conferences on specific subjects. The attendance is by invitation only; the typical size is 100 attendees. Formal papers are given, although intensive informal discussion is encouraged. Proceedings of these conferences are published (usually entirely in English) by North Holland.

3. IFIP congresses. These large, open conferences, which take place every three years, are organized in a manner similar to the National Computer Conference (NCC) meetings in the United States. Papers are solicited and refereed in the usual manner, there are many invited speakers to promote interest, and proceedings are published and widely available. IFIP 1977 was held in Toronto, IFIP 1980 was held in Japan and Australia, and IFIP 1983 will meet in Paris.

All IFIP proceedings (both formal publications and informal discussion) are in English; thus there is no language barrier for U.S. participants. The United States currently has a fairly high level of participation in many IFIP activities, yet its level of participation is below that of several European countries. Continued and increased participation in IFIP activities would be one effective way of providing opportunities for the direct personal contact that is necessary to the effort to make technical materials more accessible. In this respect, WG meetings are probably the most valuable form of contact. They affect a small but significant group of computer scientists. IFIP congresses can potentially involve a much larger segment of the community, but like any large conference, they are less effective environments for the interchange of ideas. Working conferences fall between these two extremes.

The major need for support of IFIP activities is travel funding for U.S. participants. Several European countries, for example the Federal Republic of Germany, provide funding in a special category for support of travel to IFIP meetings. A relatively small expenditure can make a significant difference in levels of participation. In the United States, it is difficult to obtain funding for foreign travel in general. In some cases, eminent computer scientists have had considerable difficulty in obtaining NSF funding to attend WG meetings. In view of the importance of IFIP activities in providing a vital forum for the interchange of ideas and for keeping U.S. computer scientists aware of activities in other countries, a significant increase in appropriate travel subsidies supporting IFIP activities is strongly recommended.

Chapter 7

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

SUMMARY AND CONCLUSIONS

Computer science has emerged as a major international activity of considerable consequence. It is being supported extensively and intensively in all countries, whether undeveloped, underdeveloped, industrial, or postindustrial. Electronic machines and systems are being applied pervasively to the solution of many problems. Many believe that electronic systems can raise the productivity of our industrial work force to its uppermost limits while transforming society into a population of those who work with their minds.

American computer scientists generally make good use of materials published in English but have difficulties keeping abreast of rapid advancements published in a foreign language, especially if that language is not part of our ethnic and cultural heritage. With computerized language translation still in its infancy and voice recognition-response systems barely off the drawing boards, existing language barriers between nations and scientists alike remain the most formidable obstacle to the free and effective exchange of ideas necessary to develop these technologies further.

The panelists' five sets of conclusions, one set for each of the five geographical areas, are functionally dependent upon specific socioeconomic and linguistic constraints inherent in the five regions; and their recommendations are equally specific. Yet these findings and suggested courses of action do contain some common threads, some fundamental principles. We have condensed these below into sets of general conclusions and general recommendations, but we suggest strongly that the reader pay heed to the more specific conclusions and recommendations contained in Chapters 1 through 5.

GENERAL CONCLUSIONS

1. A considerable amount of information on worldwide computer science developments is available in documented form, but it is not always readily accessible to the U.S. computer science community.

2. Personal contacts between U.S. and foreign computer scientists have created a powerful and effective international infrastructure

within which research results are disseminated freely, albeit with some delays.

3. Monitoring of foreign computer science publications greatly enhances our understanding of foreign science policy and its implementation.

4. Currently, translation into English often introduces serious delays before important developments abroad come to the attention of scientists in the United States.

5. Several countries are in the process of emerging from their underdeveloped status, and we can expect their scientific programs to accelerate markedly during the coming decades.

GENERAL RECOMMENDATIONS

1. A second phase of the work of this panel should be begun. Phase II would be a pilot effort designed to show the feasibility and utility of its work, which could subsequently be taken over by an existing private organization, such as the American Federation of Information Processing Societies or the Association for Computing Machinery. The plan for Phase II would be as follows:

(a) Through a limited number of carefully planned visits to countries where significant work is being done (primarily Japan), panel members would obtain firsthand knowledge of research work in foreign universities and industrial laboratories. In addition to making and/or maintaining personal contacts, they could provide answers to such questions as these: (1) Is the best and most important work being published; if so, in what language? (2) What is the time lag between the completion of work and its publication? (3) Is it feasible to establish channels of communication to get prepublication information?

(b) A staff expert retained for the purpose would develop an annotated bibliography of published material annually, which would include a qualitative assessment of the material. This bibliography would provide the basis for a summary of major developments in computer science in the areas considered, which would be published annually. Financial support from industry and/or government for some aspects of this work will be essential. The panel should determine whether some existing publication is already filling this function. For example, OHMSHA Publishing Company, Tokyo, is about to begin publishing "Yearbooks, Japan Annual Reviews in Electronics, Computers and Telecommunications" in English.

(c) The panel would investigate and make recommendations on whether centers of expertise for various overseas areas should be established. Such centers might be established in the country of interest rather than in the United States.

(d) The panel, together with a staff expert retained for the purpose, would select the best of the literature published in Japanese in each year of the panel's work and translate it into

English. In addition, the panel would recommend a procedure for carrying out the necessary translations on a continuing basis. Specific articles and books would be recommended as additional candidates for translation. The panel should identify strong researchers in Japan and closely follow their research results and papers to determine still other candidates for translation. The establishment and use of centralized data base systems to collect all the commercially and privately translated materials should be given high priority.

(e) During the second year of its activity, the panel would endeavor to negotiate an arrangement for some existing organization to continue the panel's work.

2. A funded program should be established under which select foreign publications with significant stature in computer science are abstracted in English, facilitating subsidized publication of titles, abstracts, and papers in a reputable U.S. journal.

3. A funded computer sciences foreign exchange program should be established to provide both language training and select work opportunities in the most advanced countries.

4. A policy position should be developed and a program funded, chartered to support senior computer scientists participating in select international activities of approved organizations such as the International Federation for Information Processing (IFIP) and the International Council for Computer Communication (ICCC).

5. Guidelines and mechanisms should be developed to provide greater visibility for and improved accessibility to foreign-language computer science literature now abstracted or translated into English.

APPENDIXES

Appendix A

SPEAKERS AND TITLES OF LECTURES AT THE FGCS CONFERENCE

Keynote Speech

Challenge for Knowledge Information Processing Systems (Preliminary Report on Fifth-Generation Computer Systems)
T. Moto-oka, University of Tokyo

Overview Report

What is Required of the Fifth-Generation Computer--Social Needs and Its Impact
H. Karatsu, Technology Consultant

Aiming for Knowledge Information Processing Systems
K. Fuchi, ETL

Fifth-Generation Computer Architecture
H. Aiso, Keio University

Knowledge Information Processing Research Plan

Problem Solving and Inference Mechanisms
K. Kurukawa, ETL

Knowledge Base Mechanisms
M. Suwa, ETL

Intelligent Man-Machine Interface
Ho. Tanaka, ETL

Logic Programming and a Dedicated High-Performance Personal Computer
T. Yokoi, ETL

Architecture Research Plan

New Architectures for Inference Mechanisms
S. Uchida, ETL

New Architecture for Knowledge Base Mechanisms
M. Amamiya, NTT

VLSI and System Architecture--The Development of System 5G
K. Sakamura, University of Tokyo

Preliminary Research on Data Flow Machines and Data Base Machines as the Basic Architecture of Fifth-Generation Computer Systems
Hi. Tanaka, University of Tokyo

Invited Lectures--Knowledge Information Processing

Innovation in Symbol Manipulation in the Fifth-Generation Computer Systems
E.A. Feigenbaum, Stanford University (USA)
Logical Program Synthesis
W. Bibel, Technical University, Munich (FRG)
The Scope of Symbolic Computation
G. Kahn, INRIA (France)

Invited Lectures--Architecture

A Cognitive Architecture for Computer Vision
B.H. McCormick, University of Illinois (USA)
Fifth-Generation Computer Architecture Analysis
P.C. Treleaven, University of Newcastle-Upon-Tyne (UK)
Algorithms, Architecture, and Technology
J. Allen, MIT (USA)

Panel Discussion I: Knowledge Information Processing

Chairman, K. Fuchi, ETL (Japan); panelists: E.A. Feigenbaum, Stanford University (USA), W. Bibel, Technical University, Munich (FRG), G. Kahn, INRIA (France), M. Nagao, Kyoto University (Japan), S. Osuga, University of Tokyo (Japan), and K. Furukawa, ETL (Japan)

Panel Discussion II: Fifth-Generation Computer Architecture

Chairman, H. Aiso, Keio University (Japan); panelists: B.H. McCormick, University of Illinois (USA), P.C. Treleaven, University of Newcastle-Upon-Tyne (UK), J. Allen, MIT (USA), E. Goto, University of Tokyo (Japan), S. Uchida, ETL (Japan), and T. Uraki, Hitachi (Japan)

Panel Discussion III: Impact of the Fifth-Generation Computer System

Chairman, T. Moto-oka, University of Tokyo (Japan); panelists: J.-L. Lions, INRIA (France), C. Read, Inter-Bank Research Organization (UK), P.J. Riganati, NBS (USA), S. Okamatsu, MITI (Japan), I. Toda, Electrical Communication Laboratory, NTT (Japan), and N. Szyperski, GMD (Society for Mathematics and Data Processing) (FRG)

Appendix B

GOVERNMENT-SUPPORTED PROJECTS THAT MITI PLANS TO FUND DURING FISCAL YEAR 1982

Basic Technology Development for the Next Generation (Fourth-Generation) Computers

This is a continuing five-year project that started in 1979 with emphasis on software technology (e.g., operating systems) and computer peripherals.

Budget for 1981: Y6.2 billion ($27 million)
Budget request for 1982: Y5.785 billion ($24.6 million)

Development of Fundamental Technologies for Computer System (R&D of FGCS)

In order to develop revolutionary and user-friendly computer systems that would be required in the 1990s, the project will start in 1982 research and development of basic theories and technologies such as inference structure based on data flow machines and knowledge base systems.

Budget for 1981: Y15 million ($65,000)
Budget request for 1982: Y509 million ($2.2 million)

R&D for High-Speed Scientific Computers

The project will start research and development of a high-speed computation system that will be required for plasma simulation (of the nuclear fusion) and image processing of weather-forecasting satellites, and so on.

Budget for 1981: Y30 million ($130,000)
Budget request for 1982: Y825 million ($3.5 million)

Development of Software-Related Technologies

1. The Information Processing Promotion Association opened the "Gijutsu (Technology) Center," which invites researchers from

information-processing companies and users to develop new application software.

2. It will strengthen the "Entrusted Development" (Itaku-Kaihatsu) System to promote development and effective dissemination of general purpose programs by means of "packaged programs." National and state universities and research institutions are encouraged to participate in this "nationalization" of programs.

3. The software maintenance technology development program that began in 1981 will be continued to tackle the increasing software maintenance costs.

Budget for 1981: Y2.658 billion ($11.5 million)
Budget request for 1982: Y2.66 billion ($11.5 million)

OEIC (Optoelectronic Integrated Circuit)

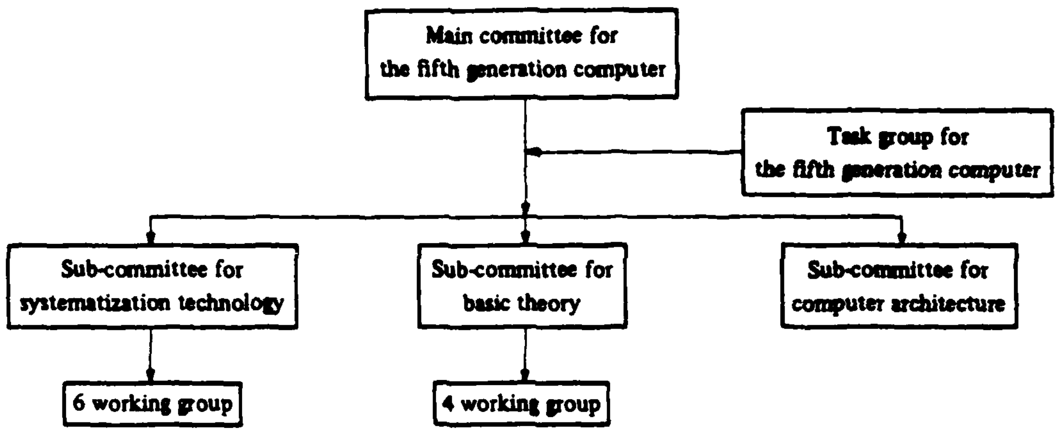
OEIC is a monolithic array of laser diodes, driving circuits, and photodetectors integrated on GaAs substrates. The Y18 billion ($78 million) project, begun in 1979, is scheduled for completion by 1986, and involves 14 companies in all, along with ETL of MITI. This project aims to make Japan the leader in optical electronics technology and is viewed as an "optical version" of the MITI-sponsored VLSI project that ended in 1980.

The laboratory will be staffed by 30 engineers in 1981. Another 20 engineers will be added in 1982 (see Electronics News, March 14, 1981).

Appendix C

ORGANIZATION AND MEMBERS OF THE FIFTH-GENERATION COMPUTER COMMITTEE (1980)

The organizaton of the Fifth-Generation Computer Committee (1980) is as follows:



Organizer

Electronics Policy Division, Machinery and Information Industry Bureau, Ministry of International Trade and Industry

Secretariat

Fifth-Generation Computer Project Group, Japan Information Processing Development Center, 3-5-8, Shibakoen, Minato-ku, Tokyo, 105 Japan

Main Committee for the Fifth-Generation Computer

Tohru Moto-oka (chairman), professor, Department of Electrical Engineering, University of Tokyo
Hajime Karatsu, managing director, Matsushita Communication Industry Co., Ltd.

Hideo Aiso, professor, Department of Electrical Engineering, Keio University
Kazuhiro Fuchi, general manager, Information Sciences Division, Electrotechnical Laboratory
Hidehiko Aya, deputy general manager, Systems Headquarters, Mitsui Engineering and Shipbuilding Co., Ltd.
Yoshinobu Anraku, director, Oki Electric Industry Co., Ltd.
Osamu Ishii, general manager, Computer Sciences Division, Electrotechnical Laboratory
Sumio Ishizaki, district manager, The Fuji Bank, Ltd.
Tadahiko Kamijo, director, Development and Promotion Department, Information Technology Promotion Agency
Toshiyasu Kunii, professor, Department of Information Science, University of Tokyo
Shohei Kurita, senior manager, Corporate Planning, Japan Electronic Computer Co., Ltd.
Kiyotake Sakaki, deputy general manager, Computer Marketing Division, Mitsubishi Electric Co., Ltd.
Makoto Nagao, professor, Department of Electrical Engineering, Kyoto University
Hirotake Nobukuni, senior staff engineer, Data Processing Division, Engineering Bureau, Nippon Telegraph and Telephone Public Corp. (NTT)
Tsuneo Uraki, general manager, Computer Product Planning Department, Kanagawa Works, Hitachi, Ltd.
Ken Hirose, professor, Department of Mathematics, Waseda University
Konomu Matsui, manager, Research Division, Institute for the Future Technology
Yukio Mizuno, associate senior vice president and director, Nippon Electric Co., Ltd.
Eiichi Wada, professor, Department of Mathematical Engineering and Instrumentation Physics, University of Tokyo
Kinko Yamamoto, general manager, Development Department, Japan Information Processing Development Center
Hiroshi Yamada, director, Fujitsu Laboratory
Eiichi Yoneda, vice chief engineer, Computer Division, Toshiba Corp.

<u>Task Group for the Fifth-Generation Computer</u>

Tohru Moto-oka, professor, Department of Electrical Engineering, University of Tokyo
Kazuhiro Fuchi, general manager, Information Sciences Division, Electrotechnical Laboratory
Hajime Karatsu, managing director, Matsushita Communication Industry Co., Ltd.
Hideo Aiso, professor, Department of Electrical Engineering, Keio University
Ken Sakamura, Department of Information Science, University of Tokyo
Kiyonori Konishi, assistant chief, Data Communication System Section, Yokosuka Electric Communication Laboratory, NTT

Shun Ishizaki, Speech Processing Section, Electrotechnical Laboratory
Shun-ichi Uchida, Information Systems Section, Electrotechnical Laboratory
Ko-ichi Furukawa, senior researcher, Information Systems Section, Electrotechnical Laboratory
Toshio Yokoi, senior researcher, Machine Inference Section, Electrotechnical Laboratory

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Hidehiko Aya, manager, System Division, Mitsui Engineering and Shipbuilding Co., Ltd.
Sumio Ishizaki, district manager, The Fuji Bank, Ltd.
Hirochika Inoue, associate professor, Department of Mechanical Engineering, University of Tokyo
Tadahiko Kamijo, director, Development and Promotion Department, Information Technology Promotion Agency
Toshiyasu Kunii, professor, Department of Information Science, University of Tokyo
Kiyonori Konishi, assistant chief, Data Communication Section, Yokosuka Electric Communication Laboratory, NTT
Kohji Torii, chief, Language Processing Section, Electrotechnical Laboratory
Ko-ichi Furukawa, senior researcher, Information Systems Section, Electrotechnical Laboratory
Shohei Kurita (observer), senior manager, Corporate Planning, Japan Electronic Computer Co., Ltd.

Subcommittee for Basic Theory

Kazuhiro Fuchi (chairman), general manager, Information Sciences Division, Electrotechnical Laboratory
Takayasu Ito, professor, Department of Communication Engineering, Tohoku University
Setsuo Osuga, associate professor, University of Tokyo, Institute of Space and Spacenautical Science
Hozumi Tanaka, chief, Machine Inference Section, Electrotechnical Laboratory
Ko-ichiro Tamura, chief, Logical Systems Section, Electrotechnical Laboratory
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Toshio Yokoi, senior researcher, Machine Inference Section, Electrotechnical Laboratory
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Masahito Amamiya, staff engineer, First Research Section, Musashino Electric Communication Laboratory, NTT

Ko-ichi Furukawa (observer), senior researcher, Information Systems Section, Electrotechnical Laboratory

Shun Ishizaki (observer), Speech Processing Section, Electrotechnical Laboratory

Motoi Suwa (observer), Computer Vision Section, Electrotechnical Laboratory

Subcommittee for Computer Architecture

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Yasuo Sakama, staff engineer, Data Communication System Section, Yokosuka Electric Communication

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Masakatsu Sugimoto, assistant manager, Development Engineering Department, Fujitsu, Ltd.

Kinji Takei, chief engineer, Information Systems Laboratory, Toshiba Research Center

Hidehiko Tanaka, professor, Department of Electrical Engineering, University of Tokyo

Hiroshi Hotta, engineering manager, Systems Engineering Department, Nippon Electric Co., Ltd.

Hiroshi Yasuhara, Information Processing Systems R&D Department, Laboratory, Oki Electric Industry Co., Ltd.

Appendix D

LIST OF PAPERS IN "RESEARCH REPORTS IN JAPAN--A COLLECTION OF RECENT RESEARCH REPORTS RELATED TO THE R&D OF THE FGCS"

1. Transformation of Natural Language Descriptions into Formal Specifications in a Montague-like Framework--An Example, by K. Fuchi, ETL
2. Derivation of Logic Programs from Formal Specifications--Dijkstra's Three MAXes, by K. Fuchi, ETL
3. Predicate Logic Programming--A Proposal of EPILOG, by K. Fuchi, ETL
4. PROLOG and Natural Language Processing, by H. Tanaka and Y. Matsumoto, ETL
5. PROLOG and Data-Flow Computation Mechanisms, by T. Yokoi, ETL
6. A PROLOG-Based Production System, by M. Suwa and H. Tanaka, ETL
7. Problem Solving with PROLOG, by K. Furukawa, ETL
8. Logic Simulation in PROLOG, by S. Uchida, ETL, and T. Higuchi, Keio University
9. Description of the PROLOG Interpreter by a Concurrent Programming Language, by K. Nitta and K. Furukawa, ETL
10. The Relation Between Computation and the Proof in Logic, by S. Oyagi and K. Tamura, ETL
11. Functional Interpretation of a Logical Sentence--A Preliminary Note, by S. Oyagi and K. Tamura, ETL
12. List Processing on a Data Flow Machine, by M. Amamiya, R. Hasegawa, and H. Mikamai, NTT
13. A Database Machine Architecture Using DPNET (Data Partitioning Network) and Set Operation Engines, by Y. Oka and K. Shima, NTT
14. Large-Scale Scientific Calculation Oriented Data Flow Processing Array System, by N. Takahashi, M. Yoshida, and M. Amamiya, NTT
15. A List Processing Oriented Data Flow Machine Architecture, by M. Amamiya, R. Hasegawa, and H. Mikami, NTT
16. Valid--A High Level Functional Language for Data Flow Machines, by M. Amamiya, NTT
17. Basic Design of LISP Machine ELIS, by Y. Hibino, N. Ohsato, and K. Watanabe, NTT
18. A Logic Programming Approach to Self-Descriptive Deductive Database, by H. Okuno, NTT
19. A Linguistic Processor in a Conversational Speech Recognition System, by K. Shikano and M. Kohda, NTT

20. An Acoustic Processor in a Conversational Speech Recognition System, by R. Nakatsu and M. Kohda, NTT

21. DURAL: A Model Extension of PROLOG, by S. Goto, NTT

22. PROLOG/KR: The Language Features (A Brief Survey), by H. Nakashima, NTT

23. S-NET: A Foundation for Knowledge Representation Languages, by M. Nagao and J. Tsujii, Kyoto University

24. Some Topics of Language Processing for the Purpose of Machine Translation, by M. Nagao and J. Tsujii, Kyoto University

25. Research on Relational Data Base Machine, by Faculty of Engineering, University of Tokyo

26. Research on Associative Processing System, by Faculty of Engineering, University of Tokyo

27. Research on Procedure Level Data Flow Machine, by Faculty of Engineering, University of Tokyo

28. Distributed File Management and Job Management of Network-Oriented Operating System, by H. Tanaka and T. Moto-oka, University of Tokyo

Appendix E

ANALYSIS OF 720 ARTICLES IN 11 JOURNALS, BY AUTHOR'S COUNTRY

Below is a listing by the author's country of computer-science-related articles published in 1980. Articles with authors from different countries are listed twice. Articles in a foreign language are so indicated. Entries labeled PROC denote proceedings of conferences. The journals in this survey and the abbreviations used are as follows:

Acta	Acta Informatica
CACM	Communications of the Association for Computing Machinery
IPL	Information Processing Letters
JACM	Journal of the Association for Computing Machinery
LNCS	Springer Verlag Lecture Notes in Computer Science
MCS	Mathematics and Computers in Simulation
SJC	SIAM Journal on Computing
SPE	Software--Practice and Experience
TCS	Theoretical Computer Science
TOPLAS	Transactions of Programming Languages
IEEESE	IEEE Transactions on Software Engineering
IEEECOM	IEEE Transactions on Computers

Australia (11)
Acta 14, 107-118, Bromley
IPL 10, 25-27, GoldSchlager
IPL 11, 96-97, Colbourn, McKay
IPL 11, 119-125, Robson
IPL 11, 130-133, Bailey, Dromey
LNCS 79, p255, Tobias, PROC
SJC 9, 54-66, Brent, Traub
SPE 10, 889-896, Kerr
SPE 10, 1029-1036, Hurst
SPE 10, 673-684, Lakos
TCS 11, 39-48, Staples

Austria (4)
Acta 13, 87-108, Maurer et al.
Acta 13, 155-168, Bentley, Maurer
Acta 13, 365-378, Maurer, Nivat
IPL 11, 66-67, Urbanek

Belgium (6)
CACM 23, 286-293, Maes
IEEECOM 29, 79-88, Rahier, Jespers
IEEESE 4, 334-339, Tavernier, Notredame
IPL 10, 4-8, Olivie
IPL 11, 152-155, Paredaens, Ponsaert
JACM 27, 499-518, Engelfriet, Rozenberg

Brazil (4)
SPE 10, 355-372, Cowan et al.
TCS 11, 227-246, Hennessy, Ashcroft
TCS 11, 337-340, Netto
TOPLAS 2, 386-414, Casanova, Bernstein

Bulgaria (2)

IPL 10, 63-67, Passy
MCS 22, 133-140, van Cutsem et al.

Canada (47)

Acta 13, 39-52, Gonnet et al.
Acta 13, 87-108, Maurer et al.
Acta 13, 205-224, Tompa
Acta 13, 257-268, Rozenberg, Wood
Acta 14, 119-134, Vaishnavi et al.
CACM 23, 440-443, Compton
IEEECOM 29, 44-49, Mehra et al.
IEEECOM 290, 899-904, Jullien
IEEECOM 292, 1104-1113, Smith
IEEECOM 29, 288-299, Agarwal, Masson
IEEECOM 29, 611-617, Chanson, Sinha
IEEECOM 29, 618-631, Chin, Fok
IEEECOM 29, 710-719, Engelberg et al.
IEEESE 2, 162-169, Howden
IEEESE 6, 585-594, Taylor et al.
IEEESE 6, 595-601, Taylor et al.
IPL 10, 20-20, Deb
IPL 10, 35-36, Bui
IPL 10, 51-56, Van Leeuven, Wood
IPL 10, 68-75, Wilson, Short
IPL 10, 87-88, Santoro
IPL 10, 127-128, Kirkpatrick
IPL 10, 213-218, Meijer, Akl
IPL 10, 240-242, Booth
IPL 11, p126, Avis
IPL 11, 193-198, Petreschi, Simeone
JACM 27, 235-249, Reiter
JACM 27, 270-280, Kameda
LNCS 91, p314, Wood
MCS 22, 30-35, Carver
MCS 22, 49-54, Masliyak, Kumar
MCS 22, 188-199, Birta
MCS 22, 298-318, Carver
SJC 9, 67-84, Hennessy
SJC 9, 251-272, Morgera
SJC 9, 281-297, Corneil, Kirkpatrick
SJC 9, 583-593, George, Liu
SJC 9, 628-634, Babai et al.
SJC 9, 636-652, Cook, Rackoff
SPE 10, 21-28, Marsland, Sutphen
SPE 10, 823-834, Gujar, Fitzgerald
SPE 10, 959-972, Dedourek et al.
SPE 10, 77-96, Agarwal, Chanson
SPE 10, 355-372, Cowan et al.
SPE 10, 501-506, Horspool
TCS 11, 227-246, Hennessy, Ashcroft
TOPLAS 2, 307-320, Howden

Czechoslovakia (1)

TCS 11, 93-106, Kucera et al.

Denmark (4)

IEEESE 1, 49-52, Ravn
LNCS 86, p560, Bjorner, PROC
LNCS 98, p629, Bjorner, Oest
SPE 10, 635-658, Kornerup et al.

England (48)

CACM 23, 625-626, Pitteway, Watkinson
CACM 23, 389-394, Cheng, Feast
CACM 23, 432-440, Triance, Yow
IEEECOM, 29, 20-27, Jesshope
IEEESE 3, 278-285, Woodward et al.
IEEESE 4, 329-333, Hennell, Prudom
IEEESE 5, 489-500, Littlewood
IPL 10, 9-13, Rayword-Smith, Rolph
IPL 10, 47-50, Anderson
IPL 10, 120-123, Wallis, Silverman
IPL 10, 148-152, Barnden
IPL 10, 198-201, Burton, Lewis
MCS 22, 113-117, Evans, Benson
MCS 22, 232-241, Coulbeck
MCS 22, 256-263, Evans, Missirlis
SPE 10, 45-56, Gay
SPE 10, 57-76, Hazel
SPE 10, 765-772, Moody, Richards
SPE 10, 791-800, Triance, Yow
SPE 10, 801-816, Barnett
SPE 10, 851-888, Barnes
SPE 10, 919-934, Alty, Coombs
SPE 10, 953-958, HJames, Ireland
SPE 10, 127-134, Thimbleby
SPE 10, 135-148, Shave
SPE 10, 149-158, Hazel
SPE 10, 175-182, Hopkins
SPE 10, 183-188, Coutant, Fraser
SPE 10, 219-230, Cox, Walsh
SPE 10, 231-240, Pemberton
SPE 10, 241-246, Cornelius et al.
SPE 10, 273-382, Harland
SPE 10, 307-318, Pyle
SPE 10, 319-328, Izatt
SPE 10, 347-354, Ledd

SPE 10, 373-382, Green
SPE 10, 393-404, Stevenson
SPE 10, 427-430, Ince, Robson
SPE 10, 431-434, Brown
SPE 10, 519-523, Radford
SPE 10, 524-530, Hunt
SPE 10, 593-622, Holden, Wand
SPE 10, 659-672, Wilson
SPE 10, 707-720, Barnes
SPE 10, 751-763, Schofield et al.
TCS 11, 167-180, Bexnon
TOPLAS 2, 122-128, Arnold, Sleep
TOPLAS 2, 137-152, Wallis

Finland (4)
Acta 13, 87-108, Maurer et al.
Acta 14, 157-175, Soisaion-Soininen
IPL 11, 137-140, Erkio
IPL 11, 224-228, Pajunen

France (27)
Acta 13, 189-198, Reutenauer
Acta 13, 365-378, Mauer, Nivat
CACM 23, 584-593, Potier, Leblanc
CACM 23, 229-239, Vuillemin
IEEECOM 292, 1060-1067, Gardarin, Chu
IEEESE 4, 373-380, Läbetoulle, Pujolle
IPL 10, 99-103, Brandajn, Joly
IPL 10, 137-147, Cellary, Mayer
IPL 11, 77-80, Preperata, Vuillemin
JACM 27, 519-532, Fayolle
JACM 27, 772-796, Raoult, Vuillemin
JACM 27, 797-821, Huet
LNCS 82, p146, Sanderson, PROC
LNCS 83, p341, Rabinet, PROC
LNCS 87, p385, Bibel, Kowalski, PROC
LNCS 99, p158, Guesserian
MCS 22, 141-150, Bois, Vignes
MCS 22, 177-188, Vergnes
MCS 22, 213-230, Bensoussan et al.
SJC 9, 142-158, Flajolet, Ramshaw
SPE 10, 553-562, Vaucher
TCS 11, 181-206, Arnold, Nivat
Acta 13, 347-364, Latteaux, French
Acta 14, 39-62, Plateau, French
TCS 11, 207-220, Bougaut, French
TCS 11, 221-225, Vauquelin et al., French

Acta 14, 87-106, Phillipp, Prauss, German

Germany (47)
Acta 13, 67-86, Siekmann and Wrightson
Acta 13, 109-114, Wegener
Acta 13, 115-140, Rohrich
Acta 13, 229-256, Kastens
Acta 13, 269-286, Buening, Priese
Acta 13, 287-298, Rollik
Acta 13, 383-408, Mescheder
Acta 14, 119-134, Vaishnavi et al.
Acta 14, 175-194, Wegener
Acta 14, 243-256, Paul et al.
Acta 14, 256-270, Commentz, Sattler
Acta 14, 295-298, Kemp
Acta 14, 317-336, Moll
Acta 14, 371-390, Kroeger
Acta 14, 391-403, Paul, Reischuk
IEEESE 3, 286-290, Voges et al.
IEEESE 4, 348-356, Reuter
IEEESE 6, 539-544, Voss
IPL 10, 193-197, Broy, Wirsing
IPL 11, 70-72, Ebert
IPL 11, 87-91, Broy
IPL 11, 94-95, Calmet, Loos
IPL 11, 96-97, Colbourn, McKay
IPL 11, 147-151, Laut
IPL 11, 190-192, Majster-Cederbaum
IPL 11, 218-223, Kandzia, Mangelmann
IPL 11, 229-231, Jammel, Stiegeler
JACM 27, 412-427, Altenkamp, Mehlhorn
JACM 27, 839-850, Reischuk
LNCS 84, p535, Brauer, PROC
LNCS 89, p457, Encarnaco, PROC
MCS 22, 1-6, Neundorf
MCS 22, 7-9, Posch, Schmidt
MCS 22, 81-90, Duschtoz, Dehl
SJC 9, 441-469, Ehrig, Rosen
SJC 9, 490-508, Schoenhage
SJC 9, 729-743, Book, Brandenburg
SJC 9, 785-807, Majster
SPE 10, 935-942, Wendt
TCS 11, 123-144, Boerger, Bueny
TCS 11, 247-276, Ehrig, Rosen
TCS 11, 303-320, Blum, Mehlhorn
TCS 11, 321-330, Heintz, Sieveking

TOPLAS 2, 321-336, Broy, Krieg-Bruckner
Acta 13, 59-66, Reinsch, German
Acta 14, 87-106, Phillipp, Prauss, German
TCS 11, 107-116, Hotz, German

Greece (2)
MCS 22, 36-48, Maritsas, Frangakis
MCS 22, 242-247, Hadjidomos

Hungary (2)
SJC 9, 212-216, Babai
SJC 9, 628-635, Babai et al.

India (7)
CACM 23, 279-285, Sethi, Chatterjee
IEEECOM 29, 145-148, Mathialagan, Biswas
IEEECOM 29, 269-277, Wagh, Ganaesh
IPL 10, 111-115, Arora, Rana
IPL 11, 199-203, Arora, Rana
SPE 10, 163-174, Verman, Sharan
SPE 10, 507-518, Prasad

Iran (1)
IEEECOM 29, 385-392, Jafari et al.

Ireland (2)
SPE 10, 283-306, Patel, Purser
SPE 10, 687-696, McKeag, Milligan

Israel (20)
Acta 13, 53-58, Galil
Acta 14, 221-242, Galil
CACM 23, 645-653, Hofri
IEEESE 1, 40-48, Tamir
IPL 10, 96-98, Ben-Ari
IPL 10, 178-179, Fraenkel, Yesha
JACM 27, 60-71, Henderson, Zalcstein
JACM 27, 445-456, Shiloach
JACM 27, 474-483, Mendelson, Yechiali
SJC 9, 197-199, Galil
SJC 9, 219-224, Shiloach
SJC 9, 273-280, Rabin
SJC 9, 417-438, Galil, Seiferas
SJC 9, 758-767, Seroussi, Lempel
SJC 9, 827-846, Aspvall, Shiloach
SPE 10, 383-392, Barak, Shapir
SPE 10, 421-426, Schach
TCS 11, 341-342, Ben-Ari
TOPLAS 2, 90-121, Manna, Waldinger
TOPLAS 2, 359-385, Krzysztof et al.

Italy (15)
CACM 23, 394-395, Luccio, Pagli
IEEECOM 290, 855-863, Bongiovanni, Luccio
IEEESE 4, 320-328, Celentano et al.
IPL 10, 173-177, Bertossi
IPL 10, 180-183, Luccio, Mazzone
IPL 10, 226-230, Chun et al.
IPL 10, 231-233, Boehm et al.
IPL 11, 134-136, Romani
IPL 11, 172-179, Pettorossi
IPL 11, 193-198, Petreschi, Simeone
JACM 27, 564-579, Ghezzi, Mandrioli
LNCS 81, p596, Blazer
MCS 22, 118-126, Cennamo
SJC 9, 692-697, Bini et al.
SPE 10, 897-918, Celantano

Japan (19)
Acta 14, 135-156, Nakajima et al.
Acta 14, 359-370, Nishimurta
CACM 23, 368-378, Banno et al.
IEEECOM 29, 102-107, Funabashi et al.
IEEECOM 29, 89-96, Kita et al.
IEEECOM 29, 317-323, Kitajima
IEEECOM 29, 577-595, Hagiwara et al.
IEEECOM 29, 681-688, Nishioka et al.
IEEESE 1, 53-63, Takahashi
IPL 10, 116-119, Watanabe
IPL 10, 219-222, Nakamura, Inoue
IPL 10, 245-248, Inoue, Takanami
IPL 11, 204-210, Kawai
JACM 27, 619-632, Tsukiyama et al.
LNCS 97, p125, Osaki, Nishio
SPE 10, 11-20, Kawai
SPE 10, 29-44, Arisawa, Fuchi
SPE 10, 575-588, Muramatsu
TCS 11, 79-92, Morisaki, Sakai

Korea (2)
JACM 27, 550-563, Sahni, Cho
SJC 9, 91-103, Cho, Sahni

<u>Mexico (1)</u>
SJC 9, 509-512, Rytter

<u>New Zealand (1)</u>
IPL 10, 206-208, Doran, Thomas

<u>Poland (10)</u>
IEEECOM 29, 703-709, Weglarz
IPL 10, 21-24, Truszczynski
IPL 10, 153-158, Czaja
IPL 10, 234-239, Czaja
IPL 11, 59-65, Banachowski
JACM 27, 30-41, Pawlikowski
JACM 27, 263-269, Wasilkowski
LNCS 88, p723, Dembinski, PROC
MCS 22, 319-323, Grandek
SJC 9, 509-512, Rytter

<u>Scotland (5)</u>
IPL 10, 1-3, Gordon
LNCS 92, p171, Milner
SPE 10, 993-1008, Stephens et al.
SPE 10, 97-126, Warren
SPE 10, 329-332, McGregor, Malone

<u>South Africa (5)</u>
IEEESE 2, 219-225, Kritzinger et al.
IEEESE 4, 381-389, Kritzinger et al.
IPL 11, 180-185, Williams
IPL 11, 186-189, Williams
SPE 10, 475-488, Messerschmidt

<u>Spain (1)</u>
IPL 11, 102-109, Luque, Ripoll

<u>Sweden (3)</u>
IEEECOM 29, 482-491, Ossfeldt, Jonsson
SPE 10, 987-992, Palme
SPE 10, 205-218, Mattsson

<u>Switzerland (5)</u>
IEEECOM 29, 134-144, Zeman, Nagle
JACM 27, 313-322, Reiser, Lavenberg
SPE 10, 773-790, Kriz, Sandmayr
SPE 10, 697-706, Hoppe
TCS 11, 331-336, Gather, Strassen

<u>Taiwan (1)</u>
IPL 10, 129-131, Wang

<u>The Netherlands (25)</u>
Acta 13, 257-268, Rozenberg, Wood
Acta 13, 4 (809), 1-8, Dijsktra
Acta 14, 271-294, Nijholt
IEEECOM 290, 884-888, Jansen, Kessels
IPL 10, 51-56, Van Leeuven, Wood
IPL 10, 83-86, Vitanyi
IPL 10, 124-126, Hemerik
IPL 10, 132-136, van Emde Boas
IPL 10, 159-162, Kessels
IPL 10, 163-168, van der Nat
IPL 10, 209-212, Overmars, van Leeuven
IPL 10, 223-225, Ehrenfeucht, Rozenberg
IPL 11, 168-171, ter Bekke
IPL 11, 211-217, ten Hoopen
JACM 27, 96-117, Engelfriet et al.
JACM 27, 499-518, Engelfriet Rozenberg
JACM 27, 656-663, Ehrenfeucht, Rozenberg
LNCS 85, p671, DeBakker, van Leeuwen, PROC
LNCS 93, p253, Nijholt
SJC 9, 558-565, Lawler et al.
SJC 9, 665-671, Apt, Meertens
SPE 10, 435-474, Boom, DeJong
SPE 10, 563-574, Aretz et al.
TCS 11, 19-38, Bergsra, Klop
TOPLAS 2, 359-385, Krzysztof et al.

<u>U.S. (393)</u>
Acta 13, 21-38, Heidelberger
Acta 13, 39-52, Gonnet et al.
Acta 13, 9-20, Hoffmann
Acta 13, 141-154, Fischer et al.
Acta 13, 155-168, Bentley, Maurer
Acta 13, 169-188, Clarke
Acta 13, 189-204, Kintala, Wotschke
Acta 13, 225-228, Barstow
Acta 13, 299-324, Franta, Bilodeau
Acta 13, 325-346, Berztiss
Acta 13, 379-382, Morito, Salkin
Acta 14, 1-20, Russell
Acta 14, 21-38, Lamport
Acta 14, 63-86, Ellis

Acta 14, 195-220, Casanova, Bernstein
Acta 14, 299-316, Purdom, Brown
Acta 14, 337-358, Wand
CACM 23, 10-23, O'Neill, O'Neill
CACM 23, 14-17, Maziack
CACM 23, 17-19, Chichelli
CACM 23, 20-23, Abelson, Andreas
CACM 23, 23-34, Blinn et al.
CACM 23, 546-555, Chand, Yadav
CACM 23, 556-563, Ledgard et al.
CACM 23, 564-572, Bard
CACM 23, 573-583, Chandy, Sauer
CACM 23, 620-624, Cook, Kim
CACM 23, 627-628, Hirschberg, Sinclair
CACM 23, 628-645, Steele, Sussman
CACM 23, 676-687, Peterson
CACM 23, 689-703, Winston
CACM 23, 703-710, Samet
CACM 23, 711-721, Shoch, Hupp
CACM 23, 105-118, Lampson, Redell
CACM 23, 118-131, Walker et al.
CACM 23, 67-70, Ralston, Shaw
CACM 23, 71-80, Canon et al.
CACM 23, 81-92, Redell et al.
CACM 23, 92-105, Ousterhut et al.
CACM 23, 147-154, Ling
CACM 23, 154-158, Fraser
CACM 23, 159-162, Lee
CACM 23, 163-170, Samet
CACM 23, 171-179, Dyer et al.
CACM 23, 199-206, Gold et al.
CACM 23, 207-213, Brooks
CACM 23, 214-228, Bentley
CACM 23, 264-271, Glass
CACM 23, 272-277, Turner
CACM 23, 294-300, Gill
CACM 23, 324-331, House
CACM 23, 332-342, Chambers, Sprecher
CACM 23, 343-349, Whitted
CACM 23, 350-351, Fletcher
CACM 23, 379-388, Harel
CACM 23, 396-410, Card et al.
CACM 23, 444-465, Iverson
CACM 23, 466-474, Peterson, Budgor
CACM 23, 495-502, Hall et al.
CACM 23, 503-510, Asai
CACM 23, 511-521, Kumar, Davidson
CACM 23, 522-528, Pfaltz et al.

IPL 10, 14-19, Honeryman et al.
IPL 10, 28-31, Lloyd
IPL 10, 32-34, Zaniolo
IPL 10, 37-40, Sleator
IPL 10, 41-45, Sarwate
IPL 10, 104-107, Pagan
IPL 10, 108-110, Jazayeri
IPL 10, 76-79, Liang
IPL 10, 80-82, Blum et al.
IPL 10, 89-95, Samet, Marcus
IPL 10, 99-103, Brandajn, Joly
IPL 10, 169-172, Melville, Gries
IPL 10, 184-188, Lengauer, Tarjan
IPL 10, 189-192, Farley
IPL 10, 198-201, Burton, Lewis
IPL 10, 202-205, Savage
IPL 10, 206-208, Doran, Thomas
IPL 10, 223-225, Ehrenfeucht, Rozenberg
IPL 10, 226-230, Chun et al.
IPL 10, 243-244, Buneman, Levy
IPL 11, 110-113, Leiss
IPL 11, 68-69, Gries, Levin
IPL 11, 73-76, Liu, Demers
IPL 11, 77-80, Preperata, Vuillemin
IPL 11, 81-83, Chung et al.
IPL 11, 84-86, Yao
IPL 11, 92-93, Johnson
IPL 11, 98-101, Kanellakis
IPL 11, 115-118, Leung, Merrill
IPL 11, 127-129, Moura
IPL 11, 141-143, Dershowitz
IPL 11, 156-161, Frederickson
IPL 11, p162, Ibarra et al.
IPL 11, 163-167, Hanson
JACM 27, 1-2, Proskurowski
JACM 27, 118-122, Kannan
JACM 27, 123-127, [illegible]Millo et al.
JACM 27, 128-145, Kaplan, Ullman
JACM 27, 146-163, Bhaskaram, Sethi
JACM 27, 164-180, Wand
JACM 27, 181-190, Bender
JACM 27, 191-205, Suzuki, Jefferson
JACM 27, 3-5, Solomon, Finkel
JACM 27, 42-59, Swartz
JACM 27, 6-29, Nassimi, Sahni
JACM 27, 60-71, Henderson, Zalcstein
JACM 27, 72-80, Silberschatz, Kedem
JACM 27, 81-95, Lipton et al.
JACM 27, 96-117, Engelfriet et al.

JACM 27, 207-227, Yao
JACM 27, 228-234, Shostak, Lamport
JACM 27, 250-262, Sagiv
JACM 27, 281-286, Chow
JACM 27, 287-312, Gonzalez, Johnson
JACM 27, 313-322, Reiser, Lavenberg
JACM 27, 323-337, Towsley
JACM 27, 338-355, Krishnaswamy, Pyster
JACM 27, 356-364, Nelson, Oppen
JACM 27, 365-383, Ward, Halstead
JACM 27, 384-393, Abelson
JACM 27, 393-401, Lichtenstein, Sipser
JACM 27, 403-411, Oppen
JACM 27, 428-444, Graham et al.
JACM 27, 457-473, Trivedi
JACM 27, 474-483, Mendelson, Yechiali
JACM 27, 484-498, Abramson et al.
JACM 27, 533-549, Papademitriou, Kanellakis
JACM 27, 550-563, Sahni, Cho
JACM 27, 580-597, Sethi, Tang
JACM 27, 599-603, Aronson et al.
JACM 27, 604-618, Lee
JACM 27, 633-655, Sagiv, Yannakakis
JACM 27, 656-663, Ehrenfeucht, Rozenberg
JACM 27, 664-674, Maier
JACM 27, 675-700, Greibach, Friedman
JACM 27, 701-717, Schwartz
JACM 27, 718-735, Fisher, Hochbaum
JACM 27, 736-757, Ramakrishnan
JACM 27, 758-771, Downey et al.
JACM 27, 822-830, JaJa
JACM 27, 831-838, Ladner, Fischer
LNCS 80, p444, Chang, Fu, PROC
LNCS 90, p239, Sandford
LNCS 94, p489, Jones, PROC
LNCS 95, p248, Martin
LNCS 96, p213, Peterson
MCS 22, 11-17, Finlayson
MCS 22, 18-24, Bank, Sherman
MCS 22, 25-29, Hayes
MCS 22, 103-112, Wadia, Payne
MCS 22, 127-132, Cooke, Blanchard
MCS 22, 91-97, Houstis et al.
MCS 22, 98-102, Vichneultshz
MCS 22, 200-207, Greenspan
MCS 22, 231-232, Azadivar, Talauage
MCS 22, 248-255, Keramidas
MCS 22, 291-297, Birkhoff, Lynch
SJC 9, 1-24, Tucker
SJC 9, 104-110, Statman
SJC 9, 111-113, Wong, Easton
SJC 9, 114-120, Hartmanis
SJC 9, 121-125, Dobkin, Lipton
SJC 9, 126-129, Hirschberg
SJC 9, 130-141, Joichi et al.
SJC 9, 142-158, Flajolet, Ramshaw
SJC 9, 159-196, Rosen
SJC 9, 200-211, Lee, Wong
SJC 9, 25-45, Bloom et al.
SJC 9, 46-53, Kintala, Fischer
SJC 9, 54-66, Brent, Traub
SJC 9, 85-90, Stockmeyer, Yao
SJC 9, 91-103, Cho, Sahni
SJC 9, 225-229, Winograd
SJC 9, 230-250, Pippenger
SJC 9, 298-320, Hwong
SJC 9, 321-342, Pan
SJC 9, 342-347, Yao, Rivest
SJC 9, 375-396, Reif
SJC 9, 397-416, Constable, Sahni
SJC 9, 417-438, Galil, Seiferas
SJC 9, 441-469, Ehrig, Rosen
SJC 9, 470-489, Parker
SJC 9, 513-524, Gibbert et al.
SJC 9, 525-540, Bloom et al.
SJC 9, 541-551, Jaffe
SJC 9, 552-557, Weide
SJC 9, 566-582, Yao
SJC 9, 594-614, Brown, Tarjan
SJC 9, 615-627, Lipton, Tarjan
SJC 9, 653-665, Tai
SJC 9, 672-682, Guibas, Odlyzko
SJC 9, 683-691, Bloom, Tindell
SJC 9, 698-705, Plaisted
SJC 9, 706-712, Beyer, Hedetniemi
SJC 9, 713-728, JaJa
SJC 9, 729-743, Book, Brandenburg
SJC 9, 744-757, Nassimi, Sahni
SJC 9, 768-784, Feldman, Nigam
SJC 9, 808-826, Coffman et al.
SJC 9, 827-846, Aspvall, Shiloach
SJC 9, 847-855, Baker et al.
SPE 10, 1-10, Griswol
SPE 10, 817-822, Fraser
SPE 10, 835-848, Harrington
SPE 10, 848-943, Hansen, Fellows

SPE 10, 1009-1028, Hamlet, Haralick
SPE 10, 1037-1042, Zelkowitz
SPE 10, 973-986, Sreenivasan et al.
SPE 10, 189-204, Pauli, Soffa
SPE 10, 249-264, Morris
SPE 10, 265-272, Wetherell
SPE 10, 335-346, Barach, Fram
SPE 10, 405-418, Hart
SPE 10, 489-500, Hanson
SPE 10, 531-552, Smith
SPE 10, 623-634, Hanson
SPE 10, 721-742, Frankowska, Franta
SPE 10, 743-750, Munn, Stuart
TCS 11, 1-18, Dobkin, Reiss
TCS 11, 49-56, Pippenger
TCS 11, 59-70, Bruss, Meyer
TCS 11, 71-78, Berman
TCS 11, 117-122, Harary
TCS 11, 145-166, Rosenberg et al.
TCS 11, 247-276, Ehrig, Rosen
TCS 11, 277-302, Kozen
TOPLAS 2, 1-17, Harel
TOPLAS 2, 129-133, Comer
TOPLAS 2, 18-41, Pai, Kieburtz
TOPLAS 2, 42-55, Francez
TOPLAS 2, 56-76, Andrews, Reitman
TOPLAS 2, 77-89, Papadimitriou, Bernstein
TOPLAS 2, 90-121, Manna, Waldinger
TOPLAS 2, 153-172, Griswold, Hanson
TOPLAS 2, 173-190, Cattell
TOPLAS 2, 191-202, Davidson, Fraser
TOPLAS 2, 203-224, Fischer
TOPLAS 2, 225-233, Luckham, Polak
TOPLAS 2, 234-238, Bernstein
TOPLAS 2, 239-262, Ma, Lewis
TOPLAS 2, 269-273, Bobrow
TOPLAS 2, 274-289, Leverett, Szymanski
TOPLAS 2, 290-306, Samet
TOPLAS 2, 337-358, Clarke
TOPLAS 2, 386-414, Casanova, Bernstein
TOPLAS 2, 415-462, Graham et al.
TOPLAS 2, 465-483, Oppen
TOPLAS 2, 484-521, Schwartz
TOPLAS 2, 522-543, Ernst, Ogden
TOPLAS 2, 544-563, Landwehr
TOPLAS 2, 564-579, Gries, Levin
TOPLAS 2, 580-595, Moret et al.
IEEECOM 29, 2-19, Rauscher, Adams
IEEECOM 29, 28-32, Samet
IEEECOM 29, 33-43, Goudan, Hayes
IEEECOM 29, 50-54, Cull
IEEECOM 29, 55-58, Kodandapani, Pradham
IEEECOM 290, 864-873, Chung et al.
IEEECOM 290, 874-883, Tilove
IEEECOM 290, 889-898, Wojcik, Fang
IEEECOM 290, 905-919, Gostelow, Thomas
IEEECOM 291, 1002-1011, Ng, Avizienis
IEEECOM 291, 957-970, Doty et al.
IEEECOM 291, 971-977, Chu, Shen
IEEECOM 291, 978-985, Goundan, Hayes
IEEECOM 291, 986-993, Kandel, Francioni
IEEECOM 291, 994-1001, Samari, Schneider
IEEECOM 292, 1038-1051, Razouk, Estrin
IEEECOM 292, 1052-1059, Kermani, Kleinrok
IEEECOM 292, 1068-1079, Chen, Akoka
IEEECOM 292, 1080-1086, Flynn, Hennessy
IEEECOM 292, 1087-1094, Gonzalez, Jordan
IEEECOM 292, 1095-1103, McGraw
IEEECOM 292, 1114-1132, Kartashev, Kartashev
IEEECOM 292, 1133-1143, Wittie, van Tilborg
IEEECOM 292, 1144-1162, Lesser, Erman
IEEECOM 29, 108-115, Patterson, Sequin
IEEECOM 29, 116-124, Weissberger
IEEECOM 29, 125-133, Cliff
IEEECOM 29, 149-160, Arulpragasm et al.
IEEECOM 29, 161-179, Lenahan, Fung
IEEECOM 29, 180-190, Tabak, Lipovski
IEEECOM 29, 68-78, Haviland, Tuszynski
IEEECOM 29, 97-101, Townsend et al.
IEEECOM 29, 213-222, Parker
IEEECOM 29, 223-234, Breuer, Friedman

IEEECOM 29, 235-248, Lesser, Shedletsky
IEEECOM 29, 278-287, Reeves
IEEECOM 29, 300-307, Jenkins, Howard
IEEECOM 29, 308-316, Bruno et al.
IEEECOM 29, 337-340, Brown, Dobkin
IEEECOM 29, 341-353, Swartzlander, Gilbert
IEEECOM 29, 354-359, Wallach, Konrad
IEEECOM 29, 360-370, Finkel, Solomon
IEEECOM 29, 371-384, Lee
IEEECOM 29, 419-428, Suk, Reddy
IEEECOM 29, 429-441, Thatte, Abraham
IEEECOM 29, 442-450, Savir
IEEECOM 29, 451-460, Abramovici, Breuer
IEEECOM 29, 461-470, Mallela, Masson
IEEECOM 29, 471-481, Pradhan
IEEECOM 29, 492-500, Sedmak, Liebergot
IEEECOM 29, 501-509, Meyer et al.
IEEECOM 29, 553-562, Chung et al.
IEEECOM 29, 563-570, VanScoy
IEEECOM 29, 571-576, Bentley, Wood
IEEECOM 29, 596-603, Lam
IEEECOM 29, 604-610, Dao et al.
IEEECOM 29, 632-638, Wing, Huang
IEEECOM 29, 639-647, Dervisoglu, Sholl
IEEECOM 29, 648-656, Sutton Bredeson
IEEECOM 29, 689-693, Chang
IEEECOM 29, 694-702, Wu, Feng
IEEECOM 29, 720-731, Meyer
IEEECOM 29, 763-776, Padau et al.
IEEECOM 29, 777-790, Pradhan, Kodandapani
IEEECOM 29, 791-800, Siegel
IEEECOM 29, 801-810, Wu, Feng
IEEECOM 29, 811-817, Ellis
IEEECOM 29, 818-825, El-Dessouki, Huen
IEEESE 1, 13-23, Guttag
IEEESE 1, 2-12, Heninger
IEEESE 1, 24-31, Musser
IEEESE 1, 32-39, Basu
IEEESE 1, 64-84, Denning
IEEESE 1, 85-90, Leinbaugh
IEEESE 1, 91-109, Banerjee et al.
IEEESE 2, 118-125, Cheung
IEEESE 2, 126-137, Yau, Chen
IEEESE 2, 138-151, Booth, Wiecek
IEEESE 2, 152-161, Beck
IEEESE 2, 170-182, Basu
IEEESE 2, 183-193, Russell
IEEESE 2, 194-204, Mao, Yeh
IEEESE 2, 205-218, Chang, Cheng
IEEESE 2, 226-231, Hsia, Petry
IEEESE 3, 236-246, Weyuker, Ostrand
IEEESE 3, 247-257, White, Cohen
IEEESE 3, 258-264, Foster
IEEESE 3, 265-277, Taylor, Osterweil
IEEESE 3, 291-296, Parr
IEEESE 3, 297-303, Lomet
IEEESE 4, 313-319, Fischer, LeBlanc
IEEESE 4, 340-347, Young, Liu
IEEESE 4, 357-372, Hardgrave
IEEESE 5, 402-410, Babad, Hoffer
IEEESE 5, 411-419, Gudes
IEEESE 5, 420-434, Mekly, Yau
IEEESE 5, 435-439, Gligor, Shattuck
IEEESE 5, 440-449, Ramamoorthy, Ho
IEEESE 5, 450-453, Birrel, Needham
IEEESE 5, 454-464, Basili, Noonan
IEEESE 5, 465-479, King
IEEESE 5, 480-484, Huang
IEEESE 5, 485-488, Leung, Ramamoorthy
IEEESE 6, 506-511, Baker, Zweben
IEEESE 6, 512-518, Faiman, Kortesoja
IEEESE 6, 519-524, Chang, Fu
IEEESE 6, 525-530, Murata
IEEESE 6, 531-538, Tai
IEEESE 6, 545-552, Yau, Collofello
IEEESE 6, 553-562, Brender
IEEESE 6, 563-571, Cook
IEEESE 6, 572-584, Bentley, Shaw

USSR (2)
IPL 10, 57-62, Sabelfeld
IPL 11, 144-146, Kinber

Appendix F

ANALYSIS OF 720 ARTICLES IN 11 JOURNALS, BY SOURCE

Below is a list of computer-science-related articles published in 1980, giving page numbers, authors, and country. Articles with authors from different countries are listed twice. Articles in a foreign language are so indicated. The following journals, containing about 720 articles, are covered in this survey:

Acta Informatica
Communications of the Association for Computing Machinery
Information Processing Letters
Journal of the Association for Computing Machinery
Springer Verlag Lecture Notes in Computer Science
Mathematics and Computers in Simulation
SIAM Journal on Computing
Software--Practice and Experience
Theoretical Computer Science
Transactions of Programming Languages
IEEE Transactions on Software Engineering
IEEE Transactions on Computers

Many of the Springer Verlag Lecture Notes are proceedings of conferences; these are marked PROC.

Acta Informatica 13 (1980)
1-8, Dijsktra, The Netherlands
9-20, Hoffmann, U.S.
21-38, Heidelberger, U.S.
39-52, Gonnet et al., U.S.
39-52, Gonnet et al., Canada
53-58, Galil, Israel
59-66, Reinsch, Germany, German
67-86, Siekmann and Wrightson, Germany
87-108, Maurer et al., Austria
87-108, Maurer et al., Finland
87-108, Maurer et al., Canada
109-114, Wegener, Germany
115-140, Rohrich, Germany
141-154, Fischer et al., U.S.
155-168, Bentley, Maurer, U.S.
155-168, Maurer, Austria
169-188, Clarke, U.S.
189-198, Reutenauer, France
189-204, Kintala, Wotschke, U.S.
205-224, Tompa, Canada
225-228, Barstow, U.S.
229-256, Kastens, Germany
257-268, Wood, Canada
257-268, Rozenberg, The Netherlands
269-286, Buening, Priese, Germany
287-298, Rollik, Germany
299-324, Franta, Bilodeau, U.S.
325-346, Berztiss, U.S.

AD-A115 140 NATIONAL RESEARCH COUNCIL WASHINGTON DC STANDING PAN--ETC F/G 9/2
INTERNATIONAL DEVELOPMENTS IN COMPUTER SCIENCE.(U)
JUN 82 F E ALLEN, J T SCHWARTZ, I L AUERBACH N00014-81-C-0274
UNCLASSIFIED TR-001 NL

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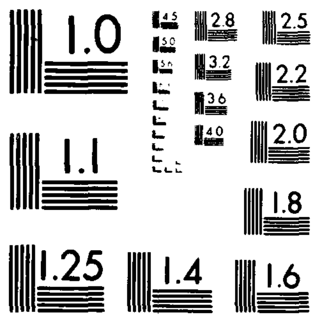

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963 A

347-364, Latteaux, France, French
365-378, Mauer, Nivat, Austria
365-378, Mauer, Nivat, France
379-382, Morito, Salkin, U.S.
383-408, Mescheder, Germany

Acta Informatica 14 (1980)

1-20, Russell, U.S.
21-38, Lamport, U.S.
39-62, Plateau, France, French
63-86, Ellis, U.S.
87-106, Phillipp, France, German
87-106, Prauss, Germany, German
107-118, Bromley, Australia
119-134, Vaishnavi et al., Canada
119-134, Vaishnavi et al., Germany
135-156, Nakajima et al., Japan
157-175, Soisaion-Soininen, Finland
175-194, Wegener, Germany
195-220, Casanova, Bernstein, U.S.
221-242, Galil, Israel
243-256, Paul et al., Germany
256-270, Commentz, Sattler, Germany
271-294, Nijholt, The Netherlands
295-298, Kemp, Germany
299-316, Purdom, Brown, U.S.
317-336, Moll, Germany
337-358, Wand, U.S.
359-370, Nishimurta, Japan
371-390, Kroeger, Germany
391-403, Paul, Reischuk, Germany

Software--Practice and Experience 10 (1980)

1-10, Griswol, U.S.
11-20, Kawai, Japan
21-28, Marsland, Sutphen, Canada
29-44, Arisawa, Fuchi, Japan
45-56, Gay, England
57-76, Hazel, England
77-96, Agarwal, Chanson, Canada
97-126, Warren, Scotland
127-134, Thimbleby, England
135-148, Shave, England
149-158, Hazel, England
163-174, Verman, Sharan, India
175-182, Hopkins, England
183-188, Coutant, Fraser, England
189-204, Pauli, Soffa, U.S.
205-218, Mattsson, Sweden
219-230, Cox, Walsh, England
231-240, Pemberton, England
241-246, Cornelius et al., England
249-264, Morris, U.S.
265-272, Wetherell, U.S.
273-282, Harland, England
283-306, Patel, Purser, Ireland
307-318, Pyle, England
319-328, Izatt, England
329-332, McGregor, Malone, Scotland
335-346, Barach, Fram, U.S.
347-354, Ledd, England
355-372, Cowan et al., Canada
355-372, Cowan et al., Brazil
373-382, Green, England
383-392, Barak, Shapir, Israel
393-404, Stevenson, England
405-418, Hart, U.S.
421-426, Schach, Israel
427-430, Ince, Robson, England
431-434, Brown, England
435-474, Boom, DeJong, The Netherlands
475-488, Messerschmidt, South Africa
489-500, Hanson, U.S.
501-506, Horspool, Canada
507-518, Prasad, India
519-523, Radford, England
524-530, Hunt, England
531-552, Smith, U.S.
553-562, Vaucher, France
563-574, Aretz et al., The Netherlands
575-588, Muramatsu, Japan
593-622, Holden, Wand, England
623-634, Hanson, U.S.
635-658, Kornerup et al., Denmark
659-672, Wilson, England
673-684, Lakos, Australia
687-696, McKeag, Milligan, Ireland
697-706, Hoppe, Switzerland
707-720, Barnes, England
721-742, Frankowska, Franta, U.S.
743-750, Munn, Stuart, U.S.
751-763, Schofield et al., England
765-772, Moody, Richards, England
773-790, Kriz, Sandmayr, Switzerland
791-800, Triance, Yow, England
801-816, Barnett, England
817-822, Fraser, U.S.

823-834, Gujar, Fitzgerald, Canada
835-848, Harrington, U.S.
851-888, Barnes, England
889-896, Kerr, Australia
897-918, Celantano, Italy
919-934, Alty, Coombs, England
935-942, Wendt, Germany
943-948, Hansen, Fellows, U.S.
953-958, HJames, Ireland, England
959-972, Dedourek et al., Canada
973-986, Sreenivasan et al., U.S.
987-992, Palme, Sweden
993-1008, Stephens et al. Scotland
1009-1028, Hamlet, Haralick, U.S.
1029-1036, Hurst, Australia
1037-1042, Zelkowitz, U.S.

Theoretical Computer Science 11 (1980)

1-18, Dobkin, Reiss, U.S.
19-38, Bergsra, Klop, The Netherlands
39-48, Staples, Australia
49-56, Pippenger, U.S.
59-70, Bruss, Meyer, U.S.
71-78, Berman, U.S.
79-92, Morisaki, Sakai, Japan
93-106, Kucera et al., Czechoslovakia
107-116, Hotz, Germany, German
117-122, Harary, U.S.
123-144, Boerger, Bueny, Germany
145-166, Rosenberg et al., U.S.
167-180, Bexnon, England
181-206, Arnold, Nivat, France
207-220, Bougaut, France, French
221-225, Vauquelin et al., France, French
227-246, Hennessy, Ashcroft, Brazil
227-246, Hennessy, Ashcroft, Canada
247-276, Ehrig, Rosen, U.S.
247-276, Ehrig, Rosen, Germany
277-302, Kozen, U.S.
303-320, Blum, Mehlhorn, Germany
321-330, Heintz, Sieveking, Germany
331-336, Gather, Strassen, Switzerland
337-340, Netto, Brazil
341-342, Ben-Ari, Israel

Mathematics and Computers in Simulation 22 (1980)

1-6, Neundorf, Germany
7-9, Posch, Schmidt, Germany
11-17, Finlayson, U.S.
18-24, Bank, Sherman, U.S.
25-29, Hayes, U.S.
30-35, Carver, Canada
36-48, Maritsas, Frangakis, Greece
49-54, Masliyak, Kumar, Canada
81-90, Duschtoz, Dehl, Germany
91-97, Houstis et al., U.S.
98-102, Vichneultshz, U.S.
103-112, Wadia, Payne, U.S.
113-117, Evans, Benson, England
118-126, Cennamo, Italy
127-132, Cooke, Blanchard, U.S.
133-140, van Cutsem et al., Bulgaria
141-150, Bois, Vignes, France
177-188, Vergnes, France
188-199, Birta, Canada
200-207, Greenspan, U.S.
213-230, Bensoussan et al., France
231-232, Azadivar, Talauage, U.S.
232-241, Coulbeck, England
242-247, Hadjidomos, Greece
248-255, Keramidas, U.S.
256-263, Evans, Missirlis, England
291-297, Birkhoff, Lynch, U.S.
298-318, Carver, Canada
319-323, Grandek, Poland

SIAM Journal on Computing 9 (1980)

1-24, Tucker, U.S.
25-45, Bloom et al., U.S.
46-53, Kintala, Fischer, U.S.
54-66, Brent, Traub, U.S.
54-66, Brent, Traub, Australia
67-84, Hennessy, Canada
85-90, Stockmeyer, Yao, U.S.
91-103, Cho, Sahni, Korea
91-103, Cho, Sahni, U.S.
104-110, Statman, U.S.
111-113, Wong, Easton, U.S.
114-120, Hartmanis, U.S.
121-125, Dobkin, Lipton, U.S.
126-129, Hirschberg, U.S.
130-141, Joichi et al., U.S.
142-158, Flajolet, Ramshaw, France
142-158, Flajolet, Ramshaw, U.S.

159-196, Rosen, U.S.
197-199, Galil, Israel
200-211, Lee, Wong, U.S.
212-216, Babai, Hungary
219-224, Shiloach, Israel
225-229, Winograd, U.S.
230-250, Pippenger, U.S.
251-272, Morgera, Canada
273-280, Rabin, Israel
281-297, Corneil, Kirkpatrick, Canada
298-320, Hwong, U.S.
321-342, Pan, U.S.
342-347, Yao, Rivest, U.S.
375-396, Reif, U.S.
397-416, Constable, Sahni, U.S.
417-438, Galil, Seiferas, U.S.
417-438, Galil, Seiferas, Israel
441-469, Ehrig, Rosen, U.S.
441-469, Ehrig, Rosen, Germany
470-489, Parker, U.S.
490-508, Schoenhage, Germany
509-512, Rytter, Mexico
509-512, Rytter, Poland
513-524, Gibbert et al., U.S.
525-540, Bloom et al., U.S.
541-551, Jaffe, U.S.
552-557, Weide, U.S.
558-565, Lawler et al., The Netherlands
566-582, Yao, U.S.
583-593, George, Liu, Canada
594-614, Brown, Tarjan, U.S.
615-627, Lipton, Tarjan, U.S.
628-635, Babai et al., Canada
628-635, Babai et al., Hungary
636-652, Cook, Rackoff, Canada
653-665, Tai, U.S.
665-671, Apt, Meertens, The Netherlands
672-682, Guibas, Odlyzko, U.S.
683-691, Bloom, Tindell, U.S.
692-697, Bini et al., Italy
698-705, Plaisted, U.S.
706-712, Beyer, Hedetniemi, U.S.
713-728, Jaja, U.S.
729-743, Book, Brandenburg, U.S.
729-743, Book, Brandenburg, Germany
744-757, Nassimi, Sahni, U.S.
758-767, Seroussi, Lempel, Israel
768-784, Feldman, Nigam, U.S.
785-807, Majster, Germany
808-826, Coffman et al., U.S.
827-846, Aspvall, Shiloach, Israel
827-846, Aspvall, Shiloach, U.S.
847-855, Baker et al., U.S.

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79, p255, Tobias, PROC, Australia
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The Netherlands
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The Netherlands
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The Netherlands
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U.S.
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134-136, Romani, Italy
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141-143, Dershowitz, U.S.
144-146, Kinber, USSR
147-151, Laut, Germany
152-155, Paredaens, Ponsaert,
Belgium
156-161, Frederickson, U.S.
p162, Ibarra et al., U.S.
163-167, Hanson, U.S.
168-171, ter Bekke, The Netherlands
172-179, Pettorossi, Italy
180-185, Williams, South Africa
186-189, Williams, South Africa
190-192, Majster-Cederbaum, Germany
193-198, Petreschi, Simeone, Canada
193-198, Petreschi, Simeone, Italy
199-203, Arora, Rana, India
204-210, Kawai, Japan
211-217, ten Hoopen,
The Netherlands
218-223, Kandzia, Mangelmann,
Germany

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229-231, Jammel, Stiegeler, Germany

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122-128, Arnold, Sleep, England
129-133, Comer, U.S.
137-152, Wallis, England
153-172, Griswold, Hanson, U.S.
173-190, Cattell, U.S.
191-202, Davidson, Fraser, U.S.
203-224, Fischer, U.S.
225-233, Luckham, Polak, U.S.
234-238, Bernstein, U.S.
239-262, Ma, Lewis, U.S.
269-273, Bobrow, U.S.
274-289, Leverett, Szymanski, U.S.
290-306, Samet, U.S.
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321-336, Broy, Krieg-Bruckner, Germany
337-358, Clarke, U.S.
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386-414, Casanova, Bernstein, Brazil
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415-462, Graham et al., U.S.
465-483, Oppen, U.S.
484-521, Schwartz, U.S.
522-543, Ernst, Ogden, U.S.
544-563, Landwehr, U.S.
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72-80, Silberschatz, Kedem, U.S.
81-95, Lipton et al., U.S.
96-117, Engelfriet et al., U.S.
96-117, Engelfriet et al., The Netherlands
118-122, Kannan, U.S.
123-127, DeMillo et al., U.S.
128-145, Kaplan, Ullman, U.S.
146-163, Bhaskaram, Sethi, U.S.
164-180, Wand, U.S.
181-190, Bender, U.S.
191-205, Suzuki, Jefferson, U.S.
207-227, Yao, U.S.
228-234, Shostak, Lamport, U.S.
235-249, Reiter, Canada
250-262, Sagiv, U.S.
263-269, Wasilkowski, Poland
270-280, Kameda, Canada
281-286, Chow, U.S.
287-312, Gonzalez, Johnson, U.S.
313-322, Reiser, Lavenberg, Switzerland
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323-337, Towsley, U.S.
338-355, Krishnaswamy, Pyster, U.S.
356-364, Nelson, Oppen, U.S.
365-383, Ward, Halstead, U.S.
384-392, Abelson, U.S.
393-401, Lichtenstein, Sipser, U.S.
403-411, Oppen, U.S.
412-427, Altenkamp, Mehlhorn, Germany
428-444, Graham et al., U.S.
445-456, Shiloach, Israel
457-473, Trivedi, U.S.
474-483, Mendelson, Yechiali, U.S.
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81-92, Redell et al., U.S.
92-105, Ousterhut et al., U.S.
105-118, Lampson, Redell, U.S.
118-131, Walker et al., U.S.
147-154, Ling, U.S.
154-158, Fraser, U.S.
159-162, Lee, U.S.
163-170, Samet, U.S.
171-179, Dyer et al., U.S.
199-206, Gold et al., U.S.
207-213, Brooks, U.S.
214-228, Bentley, U.S.
229-239, Vuillemin, France
264-271, Glass, U.S.
272-277, Turner, U.S.
279-285, Sethi, Chatterjee, India
286-293, Maes, Belgium
294-300, Gill, U.S.
324-331, House, U.S.
332-342, Chambers, Sprecher, U.S.
332-349, Whitted, U.S.
350-351, Fletcher, U.S.
368-378, Banno et al., Japan
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389-394, Cheng, Feast, England
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432-440, Triance, Yow, England
440-443, Compton, Canada
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546-555, Chand, Yadav, U.S.
556-563, Ledgard et al., U.S.
564-572, Bard, U.S.
573-583, Chandy, Sauer, U.S.
584-593, Potier, Leblanc, France
620-624, Cook, Kim, U.S.
625-626, Pitteway, Watkinson, England
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676-687, Peterson, U.S.
689-703, Winston, U.S.
703-710, Samet, U.S.
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24-31, Musser, U.S.
32-39, Basu, U.S.
40-48, Tamir, Israel
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53-63, Takahashi, Japan
64-84, Denning, U.S.
85-90, Leinbaugh, U.S.
91-109, Banerjee et al., U.S.
118-125, Cheung, U.S.
126-137, Yau, Chen, U.S.
138-151, Booth, Wiecek, U.S.
152-161, Beck, U.S.
162-169, Howden, Canada
170-182, Basu, U.S.
183-193, Russell, U.S.
194-204, Mao, Yeh, U.S.
205-218, Chang, Cheng, U.S.

219-225, Kritzinger et al., South Africa
226-231, Hsia, Petry, U.S.
236-246, Weyuker, Ostrand, U.S.
247-257, White, Cohen, U.S.
258-264, Foster, U.S.
265-277, Taylor, Osterweil, U.S.
278-285, Woodward et al., England
286-290, Voges et al., Germany
291-296, Parr, U.S.
297-303, Lomet, U.S.
313-319, Fischer, LeBlanc, U.S.
320-328, Celentano et al., Italy
329-333, Hennell, Prudom, England
334-339, Tavernier, Notredame, Belgium
340-347, Young, Liu, U.S.
348-356, Reuter, Germany
357-372, Hardgrave, U.S.
373-380, Labetoulle, Pujolle, France
381-389, Kritzinger et al., South Africa
402-410, Babad, Hoffer, U.S.
411-419, Gudes, U.S.
420-434, Mekly, Yau, U.S.
435-439, Gligor, Shattuck, U.S.
440-449, Ramamoorthy, Ho, U.S.
450-453, Birrel, Needham, U.S.
454-464, Basili, Noonan, U.S.
465-479, King, U.S.
480-484, Huang, U.S.
485-488, Leung, Ramamoorthy, U.S.
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506-511, Baker, Zweben, U.S.
512-518, Faiman, Kortesoja, U.S.
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525-530, Murata, U.S.
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55-58, Kodandapani, Pradham, U.S.
68-78, Haviland, Tuszynski, U.S.
79-88, Rahier, Jespers, Belgium
89-96, Kita et al., Japan
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108-115, Patterson, Sequin, U.S.
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125-133, Cliff, U.S.
134-144, Zeman, Nagle, Switzerland
145-148, Mathialagan, Biswas, India
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161-179, Lenahan, Fung, U.S.
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1114-1132, Kartashev, Kartashev, U.S.
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Appendix G

SURVEY OF EIGHT WESTERN EUROPEAN CONFERENCE PROCEEDINGS

The proceedings from eight Western European conferences were examined to determine the numbers of papers by foreigners, the numbers by Americans, and the numbers not in English. The number to the left of the conference title is the Springer Verlag Lecture Notes in Computer Science number.

	Papers by Foreigners	Papers by Americans	Non-English Papers
81 Data Base Techniques for Pictorial Applications, Florence, 1979	18	14	0
83 International Symposium on Programming, Paris, April 1980	20	3	3
84 Net Theory and Applications, Proceedings of the Advanced Course, Hamburg, 1979	15	4	0
85 Conference on Automata, Languagesand Parsing, The Netherlands, July 1980	45	12	0
86 Copenhagen Winter School on Abstract Software Specifications,1979	10	4	0
87 Fifth Conference on Automated Deduction, Les Res, France, July 1980	13	17	0
89 Computer-Aided Design Modeling, Systems Engineering, CAD-Systems, (Advanced Course), Darmstadt, 1980	4	2	0
94 Semantics-Directed Compiler Generation Workshop, Aarhus, January 1980	12	5	0
TOTAL	137	61	3

Appendix H

FOURTEEN USSR COMPUTER SCIENCE JOURNALS

Automatic Control and Computer Sciences (Translation of Automatika i Vychislitel'naya Teknika), Allerton Press, Inc., 150 Fifth Avenue, New York, N.Y. 10011.

Automatic Documentation and Mathematical Linguistics (Translation of Nauchno-Teknicheskaya Informatsiya), Allerton Press, Inc., 150 Fifth Avenue, New York, N.Y. 10011. ISSN 0005-1055.

Automatic Monitoring and Measuring (Translation of Autometriya), Scientific Information Consultants, Ltd., 661 Finchley Road, London NW 2 2HN, United Kingdom. ISSN 0005-1292.

Automation and Remote Control (Translation of Automatrika i Telemekhanika), Plenum Publishing Corp., 227 W. 17th St., New York, N.Y. 10011. ISSN 0005-1179.

Cybernetics (Translation of Kibernetika), Plenum Publishing Corp., 227 W. 17th St., New York, N.Y. 10011. ISSN 0011-4235.

Differential Equations (Translation of Differentsial'nye Uravneniya), Plenum Publishing Corp., 227 W. 17th St., New York, N.Y. 10011. ISSN 0012-2661.

Engineering Cybernetics (Translation of Izv. Akad. Nauk. SSR Tekh. Kibern.), Scripta Publishing Corp., 1511 K St., N.W., Washington, D.C. 20005. ISSN 0013-788X.

Functional Analysis and Its Applications (Translation of Funksional'nyi Analiz i Ego Prilozheniya), Plenum Publishing Corp., 227 W. 17th St., New York, N.Y. 10011. ISSN 0016-2663.

Problems of Information Transmission (Translation of Problemy Peredachi Informatsii), Plenum Publishing Corp., 227 W. 17th St., New York, N.Y. 10011. ISSN 0032-9460.

Programming and Computer Software (Translation of Programmirovanie), Plenum Publishing Corp., 227 W. 17 St., New York, N.Y. 10011.

SIAM Theory of Probability and its Applications (Translation of Teoriya Veroyatnotsey i ee Primeneniya), SIAM Publications, 33 S. 17th St., Philadelphia, Pa. 19013.

Soviet Automatic Control (Translation of Automatica), Scripta Publishing Corp., 1511 K St., N.W., Washington, D.C. 20005. ISSN 0038-5328.

Soviet Mathematics (Translation of Izv. Vyssh. Uchebn. Zaved. Mat.), Allerton Press, Inc., 150 Fifth Avenue, New York, N.Y. 10011.

USSR Computational Mathematics and Mathematical Physics (Translation of Zh. Vychisl. Mat. Mat. Fiz.), Pergamon Press, Inc., Maxwell House, Fairview Park, Elmsford, N.Y. 10523. ISSN 0041-5553.

Appendix I

ANALYSIS OF NINE LATIN AMERICAN PERIODICALS

BRAZIL

Dados E Ideias: Circulation 8000; bimonthly publication in Portuguese; occasional translation of foreign articles into Portuguese.
Data News: A bimonthly industry newsletter.
Sistemas: Published by the University of Sao Paulo Center for Data Processing and System Studies; Portuguese.

COLOMBIA

DAT/IS: Independent publication on computer-related topics; Spanish.
Delta: Publication of local users group; Spanish.
Sistemas: Publication of System Engineers of Colombia; Spanish.

CUBA

Control Cibernetica Y Automatizacion: Circulation 2000; published by the Cuban Academy of Sciences and Institute of Mathematics, Cybernetics, and Computations; text in Spanish, with abstracts in English and French; dates back to 1967.

MEXICO

Informatica: Circulation 5000; Spanish.

PERU

Revista De Tecnologia Educativa: Circulation 600; published by the National University of Trujillo, Peru; reviews papers and articles in programming and cybernetics; text in Spanish, with abstracts in English, German, and Spanish.

Appendix J

BIBLIOGRAPHY ON COMPUTING IN CHINA

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12. Cheng, P.P.W. A panoramic view of Chinese academic journals today. Paper presented to the Association for Asian Studies 32nd Annual Meeting, March 21-23, 1980, Washington, D.C. 6 pp.

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